U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-258 953

Assessment of Industrial Hazardous Waste Practices, Textiles Industry

Versar, Inc, Springfield, Va

Prepared for

Environmental Protection Agency, Washington, D C Office of Solid Waste Management Programs

Jun 76

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-258 953
4. Title and Subtitle: Assessment of Industrial Hazardous Waste Practices, Textiles Industry.			5. Report Date: June, 1976
			6.
7. Author(s): E. F. Abrams, D. K. Guinan, D. Derkics			8. Performing Organization Rept. No. 469
9. Performing Organization Name and Address: Versar, Inc. 6621 Electronic Drive Springfield, Virginia 22151			10. Project/Task/Work Unit No.
			11. Contract/Grant No. EPA No. 68-01-3178
12. Sponsoring Organization Name and Address: EPA Hazardous Waste Management Division Office of Solid Waste Management Programs Waterside Mall 401 M Street, S.W., Washington, D.C. 20460			13. Type of Report & Period Covered: Final. April to December 1975.
			14.

15. Supplementary Notes

EPA Project Officer - Matthew Straus

16. Abstracts This report, which covers textiles manufacturing operations, is one of a series of several studies which examine land-destined wastes from selected industries. The textiles industry is covered under Standard Industrial Classification (SIC) 22. The textiles industry was studied because of the use of heavy metals such as chromium and copper in some of the dyeing and finishing operations. These metals can be toxic in certain concentrations and forms. The various dyes and organic chemicals used were also considered for potential hazard. The potentially hazardous wastes destined for land disposal include dye and chemical containers with residuals and wastewater treatment sludges. The amount of sludges is expected to increase as effluent guidelines limitations are implemented.

17. Key Words and Document Analysis. 17a. Descriptors

Textiles
Wool
Knit Fabric
Woven Fabric
Yarn and Stock
Carpet
Dye
Finish
Sludges
Chromium
Cobalt
Cadmium
Copper
Lead
Disposal Technology
Disposal Cost
Nickel
Zinc
Arsenic
Organics
Landfills

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

Prices subject to change

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 276
	20. Security Class (This Page) UNCLASSIFIED	22. Price

FORM NTIS-35 (REV. 3-72) USCOMM-DC 14952-P72

INDUSTRIAL HAZARDOUS WASTE PRACTICES, TEXTILES INDUSTRY

AN ASSESSMENT

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U.S. ENVIRONMENTAL PROTECTION AGENCY

1976

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

This report is the result of a study commissioned by the U.S. Environmental Protection Agency to assess the "Industrial Hazardous Waste Practices--Textiles Industry," which is one of a series of industry studies by the Office of Solid Waste Management Programs, Hazardous Waste Management Division. The studies were conducted for information purposes only and not in response to a Congressional regulatory mandate. As such, the studies serve to provide EPA with: (1) an initial data base concerning the current and projected types and quantities of industrial wastes, applicable treatment and disposal technologies and their associated costs; (2) a data base for technical assistance activities; and (3) a background for guidelines development work pursuant to Section 209 of the Solid Waste Disposal Act as amended.

The definition of "potentially hazardous waste" in this study was developed based upon contractor investigations and professional judgment. This definition does not necessarily reflect EPA thinking since such a definition, especially in a regulatory context, must be broadly applicable to widely differing types of waste streams. The presence of a toxic, flammable, explosive or reactive substance should not be the major determinant of hazardousness if there are data to represent or illustrate actual effects of wastes containing these substances in specific environments. Thus, the reader is cautioned that the data presented in this report constitute only the contractor's assessment of the hazardous waste management problem in this industry. Further, this study has not demonstrated that any of the wastes from the textiles industry are hazardous. EPA reserves its judgments pending a specific legislative mandate.

This program began on 3 April 1975 and covers the Standard Industrial Classification (SIC) 22, the textiles industry.

The basic objectives of this study are provided in the report in four major sections:

Industry Characterization

Characterizes the industry with regard to the number, location, size, and production of manufacturing establishments;

Waste Characterization

Identifies and quantifies the total wastes and potentially hazardous wastes which are or will be generated by the textiles industry in 1974, 1977 and 1983.

Treatment and Disposal Technology

Describes current practices for the treatment and disposal of potentially hazardous wastes and determines the control technologies which might be applied to reduce potential hazards presented by these wastes upon disposal; and

Cost Analysis

Estimates the cost for control technology implementation and compares this cost to total sales.

The individual elements of each of these program phases are presented in detail in their respective sections of this report.

1.2 Program Methodology

1.2.1 Data Acquisition

The data needed for this study were obtained by four different methods. The first was by reviewing published information and data in the technical literature, trade journals, government reports and technical surveys which were conducted by the industry associations. These references are cited throughout this report and are listed in Section 6.0.

The second method involved the participation of the various trade associations by informing their member companies of the objectives of this study and requesting their cooperation. As a result, the trade associations supplied information to the contractor and also reviewed the progress of the work. The American Textiles Manufacturers Institute (ATMI), the Carpet and Rug Institute (CRI) and the Northern Textiles Association (NTA) participated in the study.

The third method of data acquisition was by personal contacts and visits to eighty textile plants. A better and more thorough understanding of the generation of wastes destined for land disposal from the textiles industry was obtained through personal interviews. The following chart summarizes the number of plants visited in each of the industry categories and percentages of industry category production covered by the visits:

Summary of Textile Plants Visited by Industry Category

Industry Category	No. of Plants Visited	Percentage of No. of Plants in Category	Percentage of Category Production
A - Wool Scouring	4	24	24
B- Wool Fabric Dyeing and Finishing	7	6	6
C - Greige Goods	5	0.1	2
D - Woven Fabric Dyeing and Finishing	22	3	21
E - Knit Fabric Dyeing and Finishing	20	3	17
F - Carpet Dyeing and Finishing	11	8	32
G - Yarn and Stock Dyeing and Finishing	11	3	5
	80 Total	1.5% Average	16% Average

The fourth method of data acquisition was by the sampling and analysis of the wastewater treatment sludges at fourteen plants. Sludges were selected by the contractor for analysis because the composition of this land destined waste from the textiles industry was uncertain. The number of plants that were visited and sampled in each industry category was based on the contractor's and ATMI's prejudged relative importance of the category to the needs of the study. The number of plants sampled in the various industry categories are as follows:

Industry Category	No. of Plants Sampled
A-Wool Scouring	1
B-Wool Fabric Dyeing and Finishing	1
C-Greige Goods	0
D-Woven Fabric Dyeing and Finishing	5
E-Knit Fabric Dyeing and Finishing	3
F-Carpet Dyeing and Finishing	2
G-Yarn and Stock Dyeing and Finishing	2
Total	14

No sampling was done in Category C - Greige Goods because this industry category performs no dyeing and finishing operations and therefore generates no potentially hazardous wastes destined for land disposal. Each plant was composite sampled once per week for 4 weeks, taking samples from the clarifier underflow. The sludges were analyzed for heavy metals (preserved with nitric acid) and chlorinated organics (unpreserved). The total number of samples analyzed was 112. Details on the sampling techniques, analytical methods and results are presented in Appendix C.

1.2.2 Data Analysis

The major tasks involved in the data analysis were:

(a) to review the collected data for consistency, sufficiency, and probable accuracy;

(b) to assemble the more reliable data elements into a data base sufficient to allow meaningful projections to be made;

(c) to utilize the data base and subsequent waste generation factors to allow tabulation of waste quantities and other data on a state by state, EPA Region and national basis.

The accuracy of waste quantities for all industry categories is estimated to average about ±50 per cent. In cases where Census data or data actually measured by plant personnel were obtained, the accuracy is estimated to be as good as ±10 to 20 per cent. However, most plants never weigh or otherwise quantitatively determine their land-destined wastes and the values obtained were engineering estimates by plant personnel. Therefore, the accuracy of some estimated values could be greater than ±50 per cent.

1.3 Summary of the Study

1.3.1 Industry Characterization

Of the more than 5,000 textile plants in the U.S., 2,007 were identified as plants that generate potentially hazardous wastes destined for land disposal. These plants were the ones identified that perform dyeing and finishing operations which are the source of the potentially hazardous wastes. The remaining plants (Greige Goods Manufacture) perform only dry operations such as weaving and knitting and do not generate potentially hazardous wastes.

The industry was classified into the seven categories used in the EPA effluent limitations guidelines document (8) for this industry. These categories and the Standard Industrial Classification (SIC) codes included in each category are shown below:

Category	Process	SIC Groups Included
A	Wool Scouring	2299
B	Wool Fabric Dyeing and Finishing	2231
C	Greige Goods Manufacture	2211, 2221, 2231, 2241, 2251, 2252, 2253, 2254, 2257, 2258, 2259, 2281, 2282, 2283, 2284
D	Woven Fabric Dyeing and Finishing	2261, 2262
E	Knit Fabric Dyeing and Finishing	2251, 2252, 2253, 2254, 2257, 2258, 2259
F	Carpet Dyeing and Finishing	2272
G	Yarn and Stock Dyeing and Finishing	2269

Initial attempts to categorize the textiles industry by four-digit Standard Industrial Classification (SIC) codes proved to be an inadequate method for the purposes of this study. Reasons for this are:

a. The SIC code method of classifying the industry is obsolete. For example, SIC 2261 is the dyeing and finishing of woven cotton broadcloth and SIC 2262 is the dyeing and finishing of woven man-made fiber broadcloth. Very few plants in the industry are devoted to either 100% cotton or 100% man-made fiber cloth. Most plants are producing cloth with blends of fibers and there is no SIC code for this type of plant. This is also true in SIC 2231 (woven wool fabrics) where very few plants are producing 100% wool fabrics.

b. The SIC method of classification includes all plants in the group. For example, SIC 225 includes all knitting plants and SIC 227 includes all carpet plants. This study is concerned only with those plants that perform dyeing and finishing operations. These operations are the direct or indirect source of potentially hazardous land-destined wastes. The exception to this is Wool Scouring which is part of SIC 2299. Sludges generated by Wool Scouring wastewater treatment plants were found to contain heavy metals and chlorinated organics (see Section 3 of this report).

The textile industry is heavily concentrated in the East with 91% of the plants located in EPA Regions I, II, III and IV. Fifty per cent are located in Region IV alone. More than half of the plants employ between 20 and 500 workers with less than 10 per cent employing less than 20 workers. Eleven per cent of the plants employ over 500 workers.

Almost half of the plants visited had process equipment over 20 years old, over 40 per cent had equipment ages ranging from 5 to 20 years and less than 10 per cent were less than 5 years old.

Because of the difficulties encountered with the SIC code system mentioned above, the industry was categorized on a process basis rather a product basis. Over 69 per cent of the plants are engaged in either woven or knit dyeing and finishing.

It is estimated that the six industry categories that generate potentially hazardous wastes for land disposal collectively produce about 5,300,000 metric tons of product per year. The total production in the textiles industry, including Category C (Greige Goods), is estimated to be 8,300,000 metric tons per year. Therefore, about 64 per cent of the total production in this industry generates potentially hazardous wastes. Aside from Greige Goods Manufacture, Category D (Woven Fabric Dyeing and Finishing) is the largest producer, accounting for about 34 per cent of the production that generates potentially hazardous wastes. It is also estimated that over 56 per cent of the 5,300,000 metric tons per year of production occurs in EPA Region IV.

1.3.2 Waste Characterization *

The land-destined wastes from the textiles industry originate either directly from the manufacturing processes or from the process wastewater treatment. The various waste streams, their sources and their quantities were determined for typical plants in each of the categories of the textiles industry. They are as follows:

Category A - Wool Scouring

Waste	Source	Quantity (kg of waste/ kkg of product)
dirt and wool	sorting and blending	12
dirt and vegetable matter	scouring	26
fly and sweeps	drying, top preparation	2
wool waste	top preparation	55
wasted sludge**	wastewater treatment	570 (dry) 5,700 (wet)
retained sludge*, **	wastewater treatment	780 (dry) 7,800 (wet)

Category B - Wool Fabric Dyeing and Finishing

Waste	Source	Quantity (kg of waste/ kkg of product)
flock	carbonizing and drying	16
seams	scouring	0.7
dye containers**	dyeing	1.3
chemical containers**	dyeing, special finishing	1.6
fabric	special finishing	1.3
flock	mechanical finishing	17
fiber	wastewater pretreatment screening	25 (dry) 100 (wet)
wasted sludge**	wastewater treatment	none
retained sludge*, **	wastewater treatment	1.6 (dry) 20,000 (wet)

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Category C - Greige Goods

Waste	Source	Quantity (kg of waste/ kkg of product)
fiber and yarn	yarn preparation	32
fiber, yarn and cloth	knitting	10
fiber, yarn and cloth	weaving	11

Category D - Woven Fabric Dyeing and Finishing

Waste	Source	Quantity (kg of waste/ kkg of product)
cloth	singe and desize	0.2
cloth	mercerize	0.1
cloth	bleach and wash	0.2
cloth	mechanical finish	6
flock	mechanical finish	4
dye containers**	dye and/or print	0.5
chemical containers**	dye and/or print, applied finish	0.8
fiber	wastewater pretreatment screening	0.8 (dry) 2.8 (wet)
wasted sludge**	wastewater treatment	20 (dry) 2,300 (wet)
retained sludge*, **	wastewater treatment	67 (dry) 7,300 (wet)

Category E - Knit Fabric Dyeing and Finishing

Waste	Source	Quantity (kg of waste/ kkg of product)
cloth	dye and/or print	2
cloth	chemical finish	4
cloth	mechanical finish	3
dye containers**	dye and/or print	0.9
chemical containers**	dye and/or print and chemical finish	0.9
cloth	wash	2 (dry) 4 (wet)
fiber	wastewater pretreatment screening	0.8 (dry) 2.8 (wet)
wasted sludge**	wastewater treatment	typically none
retained sludge*, **	wastewater treatment	64 (dry) 9,600 (wet)

Category F - Carpet Dyeing and Finishing

Waste	Source	Quantity (kg of waste/ kkg of product)
yarn and sweeps	tufting	1.0
selvage	selvage trim	26
flock	fluff and shear	4
dye containers**	dyeing and printing	0.13
chemical containers**	dyeing and printing	0.18
fiber	wastewater pretreatment screening	1.2 (dry) 2.0 (wet)
latex sludge	wastewater treatment	2.3 (dry) 4.9 (wet)
wasted sludge**	wastewater treatment	typically none
retained sludge*, **	wastewater treatment	5.2 (dry) 22,000 (wet)

Category G - Yarn and Stock Dyeing and Finishing

Waste	Source	Quantity (kg of waste/ kkg of product)
yarn	bleaching/dyeing	0.7
yarn	beaming/quilling/ winding, etc.	5.4
dye containers**	dyeing	0.87
chemical containers**	dyeing and finishing	2.2
fiber	wastewater pretreatment screening	9.0 (dry) 33 (wet)
wasted sludge**	wastewater treatment	typically none
retained sludge*, **	wastewater treatment	2.9 (dry) 20,000 (wet)

* The retained sludge quantities are accumulations over the life of the pond and cannot be related to production.
** Waste streams considered to be potentially hazardous.

Of the industry's current total process wastes for land disposal, 3.6 per cent by weight (dry basis) is considered to be potentially hazardous. This potentially hazardous fraction includes dye and chemical containers with residual dyestuff and chemicals. The remaining 96.4 per cent of land destined wastes from the textile manufacturing processes are non-hazardous. The non-hazardous process wastes include lint, yarn, cloth, etc.

The sludge generated by textile plant wastewater treatment systems is also considered to be potentially hazardous. This includes both the sludge generated and retained in the wastewater treatment system and the excess sludge that is removed from the system for final disposal. Retained sludge is so slowly generated by aerated biological treatment of textile wastewaters that, in many cases, there is no need for disposal. Sludge is allowed to accumulate over a period of years (5 to 10) and is stored in the treatment pond. Wasted sludge is excess sludge generated in textile wastewater treatment systems which must be removed and disposed on a regular basis. Only the Wool Scouring and Woven Fabric Dyeing and Finishing categories typically are presently disposing of excess sludge. On a dry weight basis, wastewater treatment sludge currently comprises about 80 per cent of the total land destined potentially hazardous wastes and about 12 per cent of all wastes. Table 1-1 summarizes the total wastes, the total potentially hazardous wastes and the total hazardous constituents from the textile industry for the years 1974, 1977 and 1983. The large increase in total (dry wt.) quantity projected for 1983 is due mainly to the implementation of recommended wastewater treatment technologies in the effluent limitations guidelines document for this industry. (It should be noted that the wet weight quantities will decrease by 1983).

Figures 1-1, 1-2 and 1-3 summarize the estimated state-by-state distribution of total wastes from the textiles industry, potentially hazardous dye and chemical container wastes and potentially hazardous wastewater treatment sludges, respectively. These illustrations show that over 90 per cent of the total potentially hazardous land destined wastes from the textile industry is generated in EPA Regions I, II, III and IV. Eighty-seven per cent of all wastes are generated in those same regions.

The hazardous constituents in the waste streams were determined by plant visits and by composite sampling of wastewater treatment sludge as mentioned earlier. The hazardous constituents of the dye and chemical container waste streams were determined to be the residual dyestuff and a portion (estimated by the contractor to be 25 per cent by weight) of the residual chemicals (i.e., ortho-phenyl-phenol, biphenyl, zinc salts, etc.). The constituents identified in the wastewater treatment sludges determined to be hazardous were heavy metals such as arsenic, barium, cadmium, chromium, cobalt, copper, lead, mercury, nickel and zinc and chlorinated organic compounds. The metals and chlorinated organics were determined to be either adsorbed or included primarily in the solid phase of the sludge.

A few atypical potentially hazardous wastes were also found throughout the industry containing chlorinated organics or flammable solvents as the hazardous constituents. Also, one facility was found that disposes of yarn wet with non-fixed dyes containing dyestuff as the hazardous constituent. These atypical wastes could not be extrapolated to the entire industry nor geographically distributed because there was no way of determining how much of the industry handled or disposed of these wastes in the non-typical manner.

The criteria used for determining the concentration at which textile wastes were considered potentially hazardous were the drinking water standards for specific heavy metals and total organics. The hazardousness of dyestuff is not as easy to delineate. There is little information available on the toxicity of dyes to humans. However, bioassay

Table 1-1. Summary of Land Destined Total and Potentially Hazardous Wastes from the Textiles Industry (SIC 22), kkg/yr

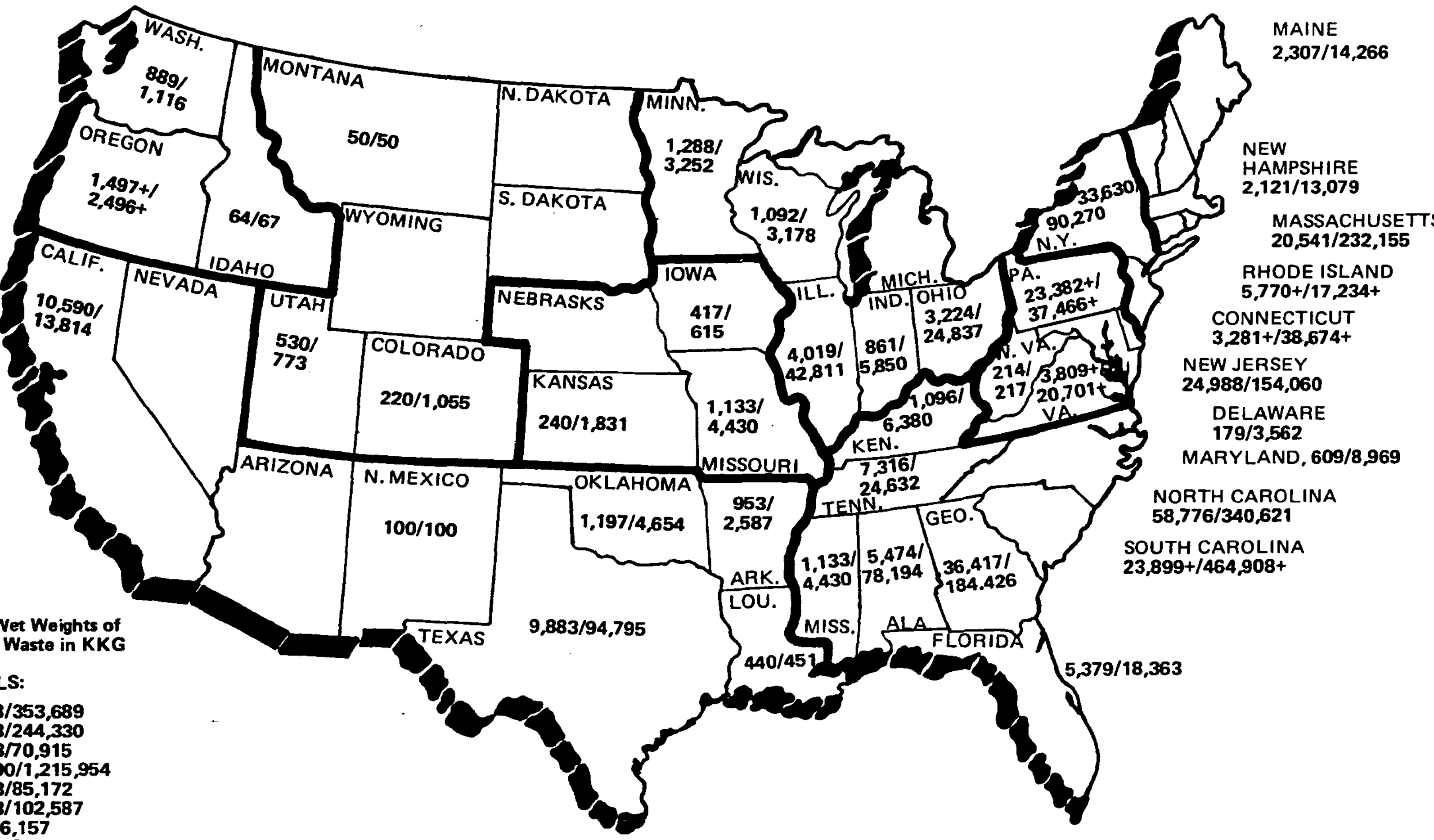
Industry Category	Total Wastes (dry/wet) 1974	1977	1983	Total Potentially Hazardous Wastes (dry/wet) 1974	1977	1983	Total Hazardous Constituents (dry) 1974	1977	1983	Specific Hazardous Constituents
A - Wool Scouring	32,000/ 261,600	32,000/ 261,600	20,900/ 63,800	25,500/ 255,000	25,500/ 255,000	14,300/ 57,200	134	134	76	heavy metals*, chlorinated organics**
B - Wool Fabric Dyeing and Finishing	19,438/ 43,533	19,438/ 43,588	46,488/ 150,958	895/ 1,720	895/ 1,720	27,900/ 111,600	7.6	7.6	2,040	heavy metals, dyestuff*** and chemicals***
C - Greige Goods	159,000/ 159,000	174,000/ 174,000	207,000/ 207,000	0	0	0	0	0	0	none
D - Woven Fabric Dyeing and Finishing	35,616/ 1,522,477	37,702/ 1,618,203	77,224/ 227,070	15,300/ 1,500,000	16,200/ 1,600,000	51,400/ 205,600	842	892	2,980	heavy metals, chlorinated organics, dyestuff & chemicals
E - Knit Fabric Dyeing and Finishing	10,448/ 13,239	11,073/ 14,065	50,002/ 162,272	1,400/ 2,590	1,490/ 2,760	38,500/ 154,000	3.4	3.7	2,020	heavy metals, chlorinated organics, dyestuff & chemicals
F - Carpet Dyeing and Finishing	23,539/ 27,359	30,061/ 34,344	67,849/ 116,522	210/ 1,170	263/ 1,470	14,600/ 58,400	1.0	1.3	817	heavy metals, chlorinated organics, dyestuff & chemicals
G - Yarn and Stock Dyeing and Finishing	30,132/ 71,367	32,000/ 75,599	64,139/ 193,137	5,080/ 6,340	5,400/ 6,740	32,500/ 130,000	36.5	38.7	1,430	heavy metals, chlorinated organics, dyestuff & chemicals
Total Textiles Industry	310,173/ 2,098,575	336,274/ 2,221,399	533,602/ 1,120,759	48,400/ 1,770,000	49,700/ 1,870,000	179,000/ 716,800	1,020	1,080	9,360	see above

* includes arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel and zinc

** individual chlorinated organic compounds were not identified in the laboratory, only total quantities

*** see Section 3.2 of this report for explanation of types of dyestuff and chemicals

Figure 1-1. ESTIMATED QUANTITIES OF TOTAL WASTE TO LAND DISPOSAL, 1974 (DRY/WET WEIGHT)



KEY:

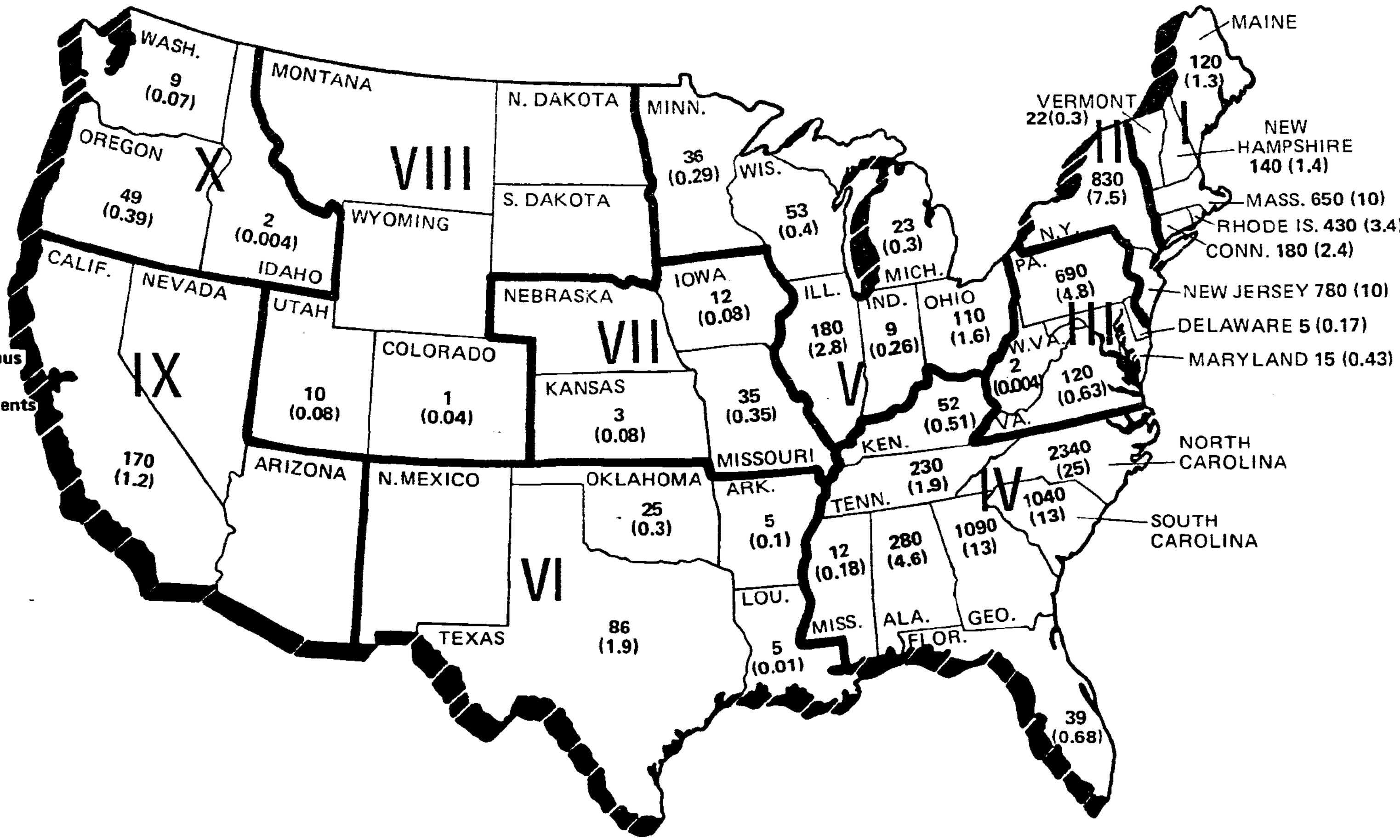
XX/XXX Dry/Wet Weights of Total Waste in KKG

REGION TOTALS:

I	–	38,328/353,689
II	–	52,618/244,330
III	–	28,193/70,915
IV	–	151,090/1,215,954
V	–	11,763/85,172
VI	–	12,573/102,587
VII	–	1,598/6,157
VIII	–	800/1,880
IX	–	10,590/13,814
X	–	2,450/3,680

+ Waste quantities from Wool Scouring Operations not included, See Table 3-2.

Figure 1-2. ESTIMATED QUANTITIES OF TOTAL POTENTIALLY HAZARDOUS DYE AND CHEMICAL CONTAINER WASTES TO LAND DISPOSAL (DRY WEIGHT), 1974



KEY:

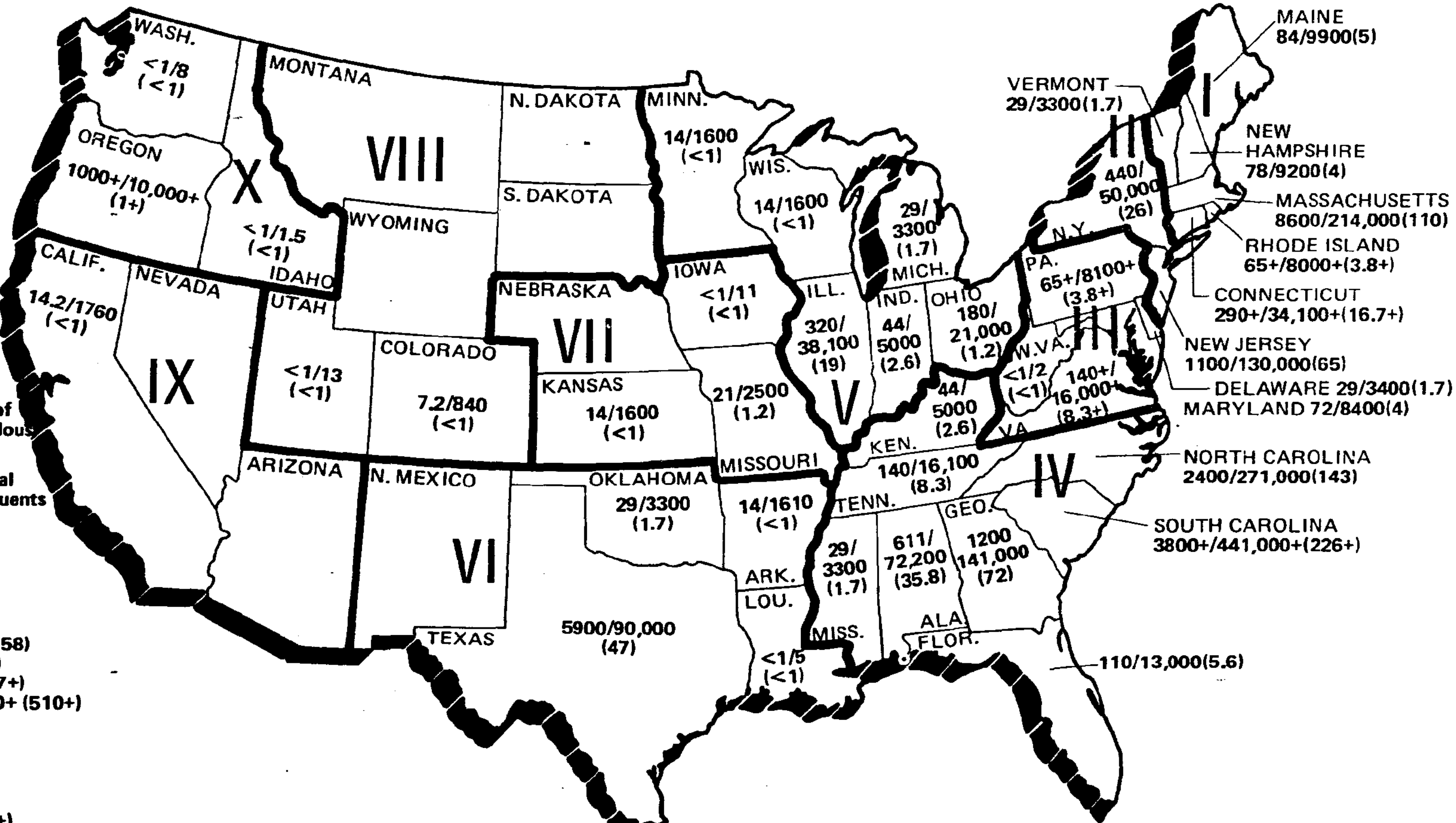
XX Total Potentially Hazardous Waste Stream in KKG

(XX) Total Hazardous Constituents in KKG

REGION TOTALS:

I	– 1550 (19)
II	– 1610 (18)
III	– 830 (6)
IV	– 5100 (70)
V	– 410 (6)
VI	– 120 (2)
VII	– 50 (0.5)
VIII	– 10 (0.1)
IX	– 170 (1)
X	– 60 (0.4)
Total U.S.	9910 (123)

Figure 1-3. ESTIMATED QUANTITIES OF TOTAL POTENTIALLY HAZARDOUS WASTEWATER TREATMENT SLUDGE TO LAND DISPOSAL, (1974) DRY/WET WEIGHT



KEY:

XX/XXX Dry/Wet Weights of Potentially Hazardous Sludge in KKG

(XX) Dry Weight of Total Hazardous Constituents in KKG

REGION TOTALS:

I	–	12,400/311,000 (158)
II	–	1540/180,000 (91)
III	–	3300+/66,000+ (37+)
IV	–	12,700+/1,000,000+ (510+)
V	–	600/70,000 (36)
VI	–	5940/95,000 (49)
VII	–	35/4100 (2)
VIII	–	7/840 (<1)
IX	–	14/1600 (<1)
X	–	1000+/10,000+ (5+)

Total U.S. – 38,400/1,760,000 (900)

studies sponsored by the American Dye Manufacturers Institute (ADMI) have shown that some dyes do exhibit appreciable toxicities to fish and algae. Other studies concerning the effects of dyes on aerobic and anaerobic systems showed that dyes are refractory to conventional aerobic biological treatment systems. However, there were indications of dye degradation under anaerobic conditions and this raises the problem of the fate of dyes in a landfill subject to anaerobic processes. There is no information available on the nature, toxicity or carcinogenicity of any metabolites resulting from dye degradation. It is possible that dyes may degrade into carcinogenic synthesis intermediates. This presents the problem of leaching of toxicants or carcinogens from landfill sludges into potential drinking water supplies. Thus, all dye-containing waste streams were determined to be potentially hazardous. This includes adsorbed dyes in wastewater treatment sludges as well as residual dyestuff discarded with containers.

The drinking water standard for specific heavy metals and total organics was also applied to residual chemicals in discarded containers as well as any chemicals adsorbed onto the sludges.

The criteria for determining the hazardousness for the atypical wastes includes the drinking water standards for total organics as well as the criteria cited above for dye-containing waste streams. The criteria applied for flammable solvents was the Department of Transportation flashpoint standard of 38° C. (25). Details of the criteria for categorizing wastes as potentially hazardous are presented in Section 3.2.

1.3.3 Treatment and Disposal Technology

Three levels of treatment and disposal technology for potentially hazardous wastes were determined for the industry. These levels are briefly defined as follows and are illustrated for the textiles industry in Figures 1-4, 1-5 and 1-6.

Level I	- broad average of current practice
Level II	- current best practice from an environmental standpoint
Level III	- technology necessary to provide adequate health and environmental protection

Table 1-2 summarizes the levels of technology determined for the various potentially hazardous waste streams in the textiles industry. Most of the industry in all categories disposes of the potentially hazardous dye and chemical containers, with residual dyestuff and chemicals, in municipal or county general purpose landfills taking no extraordinary environmental precautions. Several plants wash and clean the residual dyestuff and chemicals from the containers prior to disposal and send the small amount of wash water to wastewater treatment. This waste control practice converts a

Figure 1-4. TYPICAL MODEL OF LEVEL I TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY

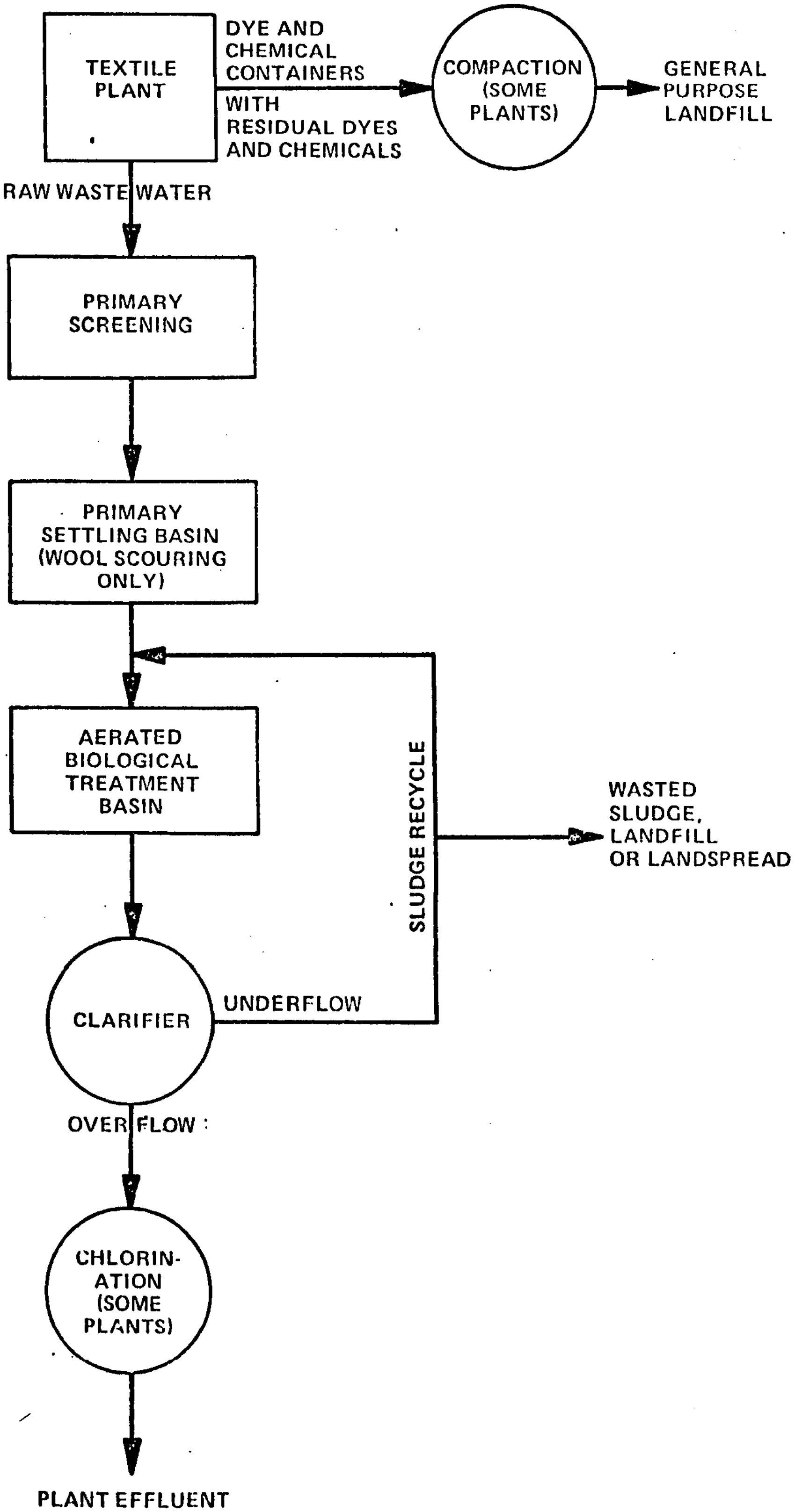


Figure 1-5. TYPICAL MODEL OF LEVEL II TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY

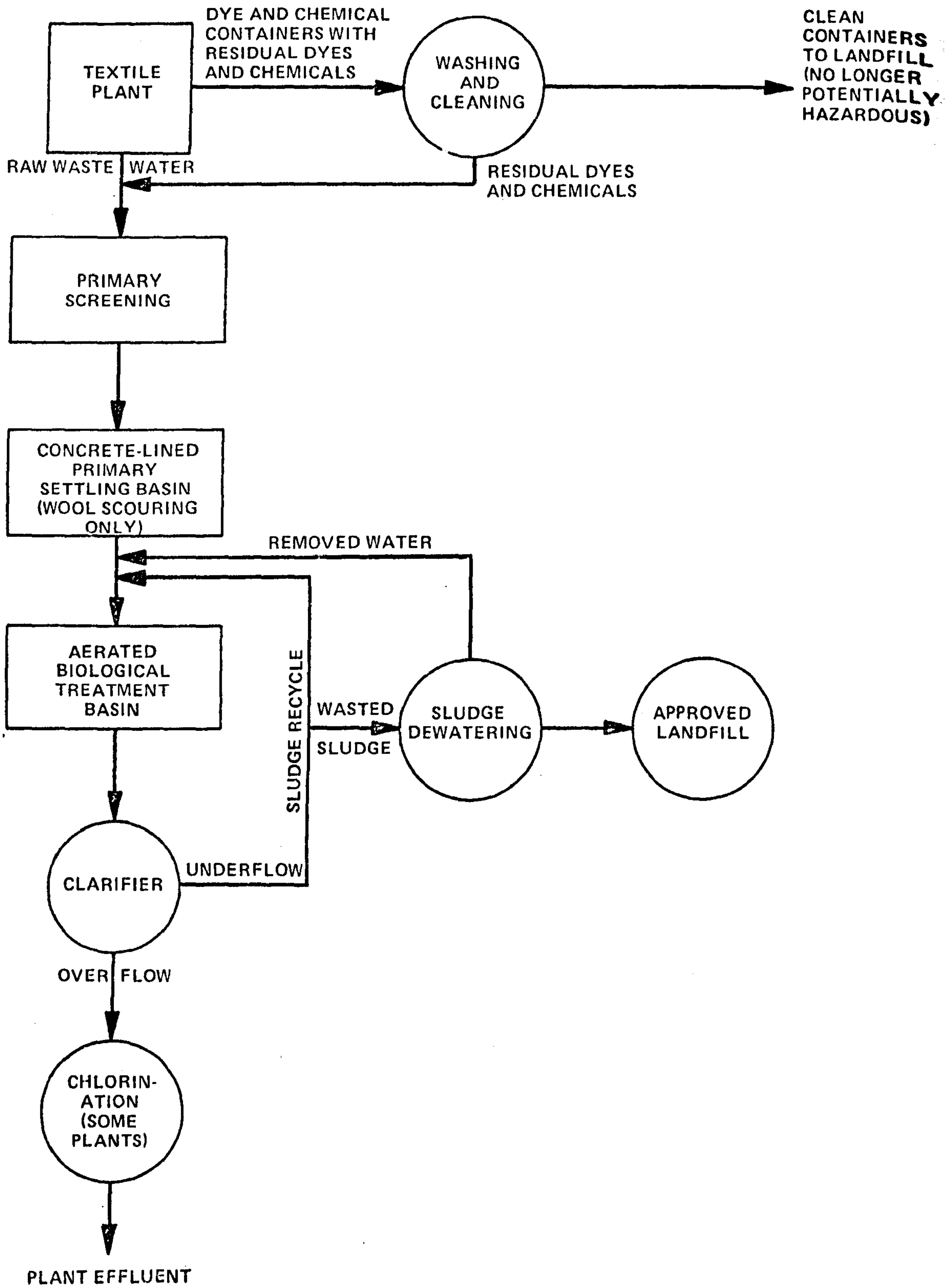


Figure 1-6. TYPICAL MODEL OF LEVEL III TECHNOLOGIES FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY

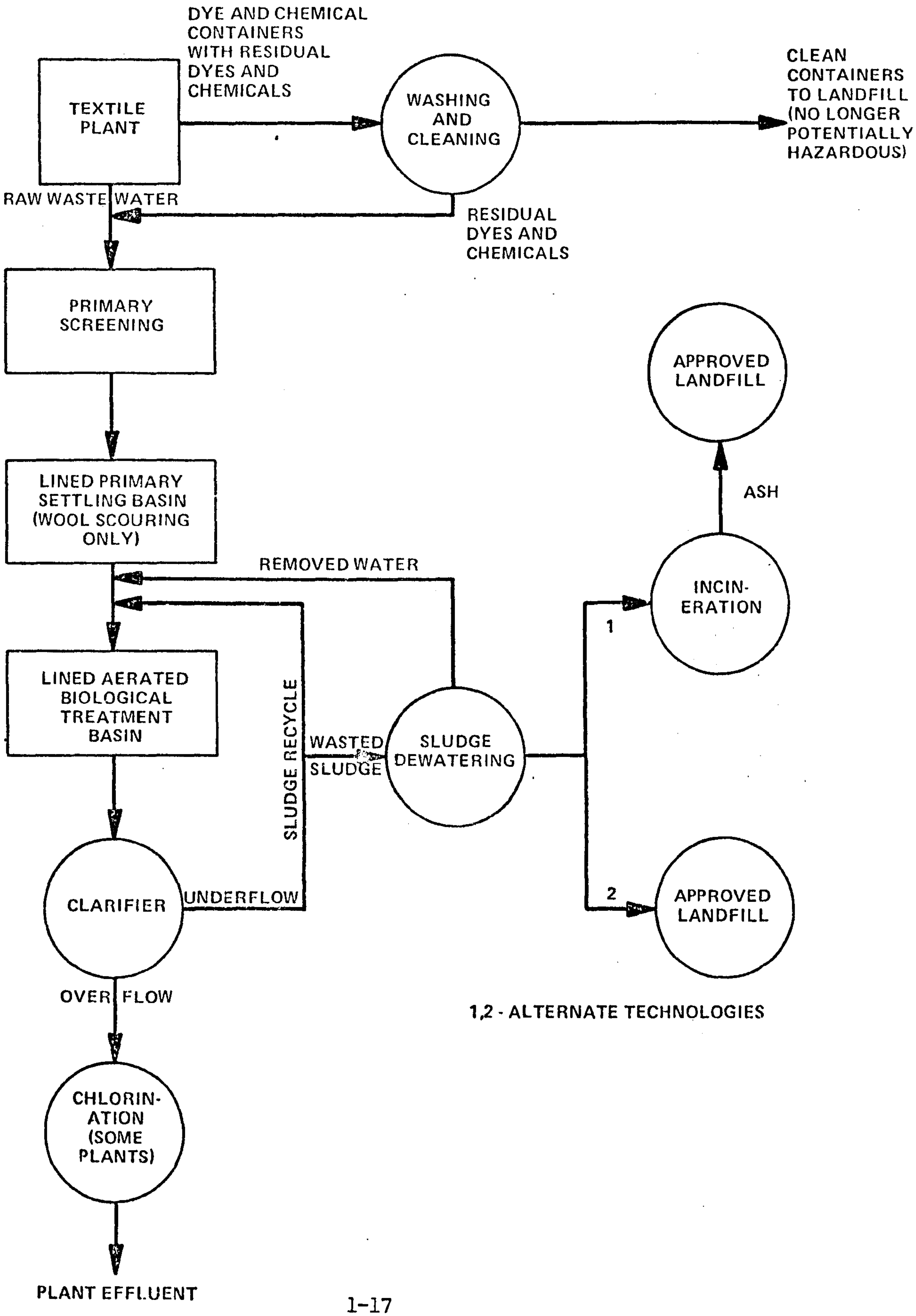


Table 1-2. Summary of the Levels of Technology Determined for the Potentially Hazardous Waste Streams in the Textiles Industry

Potentially Hazardous Waste Stream	Level I Prevalent Technology	Level II Best Available Technology	Level III Adequate Health and Environmental Protection
Dye and Chemical containers	General purpose landfilled (categories A,B,D,E,F and G)	Wash containers prior to general purpose landfilling (categories D,E and G)	Same as Level II
Wastewater treatment sludge	(1) Retention of sludge in unlined aeration ponds (categories A,B,D,E,F and G) (2) Disposal of excess sludge in general purpose landfills, dumps and/or landspreading on farm land (categories A and D)*	(1) Retention of sludge in lined aeration ponds (categories A and E) (2) Disposal of dewatered excess sludge in an approved landfill (category E)	(1) Same as Level II (2) Same as Level II
Atypical Wastes:			
Solvent recovery sludges	Drummed and general purpose landfilled (categories B,D), or stored on-site (category G)	Incineration or recovery by waste disposal contractor (category E)	Same as Level II
Lint wet with non-fixed dye	General purpose landfilled (category F)	Same as Level I	Future environmentally adequate treatment/disposal technologies include washing, approved landfilling or incineration

* Categories B, E, F and G typically were found not to have excess sludge for disposal

potentially hazardous waste into a non-hazardous waste and only slightly increases the raw waterborne waste load.

The major potentially hazardous waste generated by the textile industry was determined to be wastewater treatment sludges. Of course, sludges are generated by only those plants having their own wastewater treatment facilities. It is estimated that 488 plants of the 2,007 identified (24 per cent) which generate potentially hazardous waste have wastewater treatment facilities. (10). ATMI estimates that these 488 plants comprise 65 per cent of the total production of the 2,007 plants. The remaining 1,519 plants use municipal sewage treatment (10) which transfers the problem of potentially hazardous sludge disposal and its associated costs to the municipalities. About 7 per cent of the plants visited contributed 50 to 95 per cent of the total wastewater load to the municipal sewage treatment system. Several of the municipal treatment facilities were constructed with plant funds and turned over to the municipality for operation and maintenance.

Ninety-six per cent of the 488 plants with treatment systems are generating sludge in unlined aeration basins which have potential for percolation to underlying strata. Four per cent were found to have concrete lined aeration or settling basins. The lined ponds were found to be most prevalent in Category A, Wool Scouring, where 67 per cent of the plants use them. Category E, Knit Fabric Dyeing and Finishing, was the only other industry category found to be using lined ponds to the extent of 12 per cent of the plants in the category.

The necessity to dispose of excess sludge was found to be typical in only two industry categories, Wool Scouring and Woven Fabric Dyeing and Finishing. All plants in the Wool Scouring category find it necessary to dispose of sludge. About 40 per cent of the plants (56 per cent of the category production) engaged in Woven Fabric Dyeing and Finishing find it necessary to dispose of excess sludge. Most facilities in the other industry categories are generating sludge at a low enough rate to preclude the need to dispose of any excess.

Based on the plants visited, all plants that have dye and chemical container wastes dispose of them off-site. The ratio of on-site to off-site sludge disposal is about one to one, also based upon the plants surveyed. The typical disposal methods used are land dumping, land spreading and landfilling with no special environmental protection precautions being taken. In one instance, a plant employee hauled excess sludge to his farm and spread the sludge as fertilizer. Only one plant was found that disposed of dewatered sludge in a state approved landfill with leachate and runoff controls. See Section 4.2.6 for the definition of an approved landfill.

1.3.4 Cost Analysis

The estimated total annual costs of potentially hazardous waste treatment/disposal technologies for the entire industry at the three levels of technology are \$4,700,000, \$6,500,000 and \$11,700,000, respectively, as shown in Table 1-3. The total industry technology cost rates in terms of dollars per metric ton of product are \$0.88, \$1.23 and \$2.21, respectively. The rates in terms of dollars per metric ton of waste (wet/dry) are \$2.40/\$97, \$3.35/\$134 and \$6.03/\$242, respectively. The difference between what the industry is presently spending and what is required for adequate health and environmental protection is approximately \$7,000,000. This amounts to \$1.32 per metric ton of total production.

The technology costs as a per cent of the total sales for the various industry categories are less than 1 per cent at all three technology levels as shown in Table 1-4. The weighted average values for the entire industry at the three levels of technology are 0.07 per cent, 0.1 per cent and 0.18 per cent, respectively. For less than 0.2 per cent of the sales value, the industry as a whole can provide treatment and disposal technology for potentially hazardous land-destined wastes that will give adequate health and environmental protection. From industry category to category, this value ranges from a high of 0.9 per cent of sales value for wool scouring to none for greige goods. A somewhat wider spread of cost impacts from manufacturer to manufacturer can be expected because of local situations, but these specific impacts have not been determined.

Table 1-3. Extrapolation of Technology Costs to the Industry Categories and the Entire Textiles Industry

Industry Category	Annual Production Thousand Metric Tons	Annual Costs, 1975 Dollars *		
		Level I	Level II	Level III
A - Wool Scouring	69	850,000	988,000	1,910,000
B - Wool Fabric Dyeing and Finishing	309	13,600	13,600	
C - Greige Goods	3,000	No potentially hazardous wastes -no technology costs		
D - Woven Fabric Dyeing and Finishing	1,801	3,700,000	3,800,000	5,740,000
E - Knit Fabric Dyeing and Finishing	771	21,600	1,600,000	1,600,000
F - Carpet Dyeing and Finishing	679	3,400	3,400	400,000
G - Yarn and Stock Dyeing and Finishing	1,660	76,000	83,000	1,300,000
Total Industry	5,289**	4,664,600	6,488,000	11,704,000
Total Industry Rate				
$/kkg of product		$0.88	$1.23	$2.21
$/kkg of potentially hazardous waste (dry weight)		$97	$134	$242
$/kkg of potentially hazardous waste (wet weight)		$2.40	$3.35	$6.03

* To convert costs to December 1973 dollars, multiply by 0.82

** Does not include Category C - Greige Goods

Table 1-4. Comparison of Technology Costs with the Total Sales by Industry Category and the Entire Textiles Industry

Industry Category	Sales Value * $/kkg	Technology Costs as Per Cent of Sales Value Level I	Level II	Level III
A - Wool Scouring	3,000	0.4	0.5	0.9
B - Wool Fabric Dyeing and Finishing	1,650	0.003	0.003	0.15
C - Greige Goods	No potentially hazardous wastes - no technology costs			
D - Woven Fabric Dyeing and Finishing	1,280	0.16	0.16	0.25
E - Knit Fabric Dyeing and Finishing	1,840	0.0015	0.11	0.11
F - Carpet Dyeing and Finishing	1,850	0.0003	0.0003	0.032
G - Yarn and Stock Dyeing and Finishing	450	0.01	0.01	0.17
Weighted Average for Entire Industry	1,218	0.07	0.1	0.18

* 1975 Dollars

2.0 DESCRIPTION OF THE TEXTILES INDUSTRY

2.1 Introduction*

The textiles industry produced approximately $35 billion worth of fabrics (as measured by plant shipments) for various uses in 1974. The major uses of textile fabrics are for apparel (38 per cent); home furnishings (31 per cent); other consumer products, such as piece goods for home sewing, medical, surgical and sanitary products (11 per cent); and industrial products, such as transportation fabrics, hose and belting, filtration and protective fabrics (17 per cent). Exports account for the remaining 3 per cent.

The markets for apparel and home furnishings are very much influenced by general economic conditions. In particular the apparel market is closely related to the level of disposable income. In recent years apparel expenditures have averaged approximately 6.5 per cent of disposable income. The home furnishings market is influenced in addition by new family formations and the consequent demand for new housing.

The market for other consumer products is basically influenced by population growth, but under adverse economic conditions will make temporary gains at the expense of the apparel and home furnishing markets.

The specialized markets for industrial fabrics have shown good growth in recent years. Further growth in these markets will depend largely on the development of new products.

Textile exports rose sharply in 1973 and 1974, because of rising world demand and assisted by the lower prices of American textiles in the world market, as a result of dollar devaluation. However, by early 1975, exports were running below those of a year earlier. This reversal was due to generally softening of demand in the world markets and to the intensification of price competition.

2.2 Discussion of the Textiles Industry **

2.2.1 Products of the Industry

Textile fabrics are produced by the weaving or knitting of fibers. At some point in the manufacturing process the fiber, yarn, or fabric is bleached, finished and dyed or printed as dictated by the needs of the finished product.

The major products of the textile industry are:

* All data in Section 2.1 were obtained from Reference 1
** All data in Section 2.2 were obtained from Reference 1

(a) Apparel. This segment of the market represents 38 per cent of the textiles produced in this country. Apparel usage is closely tied to the growth in disposable personal income. During the 1960's, expenditures for apparel production was approximately 93 per cent of the growth in disposable income for the decade. For the 1970-74 period, growth in apparel usage was about 40 per cent compared to a disposable income increase of 41.5 per cent. These unusually high percentage gains, however, were the result in part to the rapid inflation in 1973 and 1974. Spending for apparel should continue to grow, although possibly at a lower rate, with most of the growth coming from a greater representation of the 20 to 39-year-old segment of the U.S. population (which encompasses the biggest spenders for apparel), and from upgrading of living standards by lower income groups.

(b) Home Furnishings. Home furnishings account for 31 per cent of the textile industry.

The major textile products for home furnishings are draperies, furniture fabrics and upholstery, sheets, bedding material, blankets, carpets and rugs.

This market segment approximately doubled during the 1960's. By the end of the decade, consumer expenditures at the retail level exceeded $37 billion, and in 1974 rose to nearly $59 billion. Noteworthy is that as a percentage of total consumer expenditures, these outlays also show a steady increase from 5.8 per cent in 1960 to 6.4 per cent in 1969 and then to 6.7 per cent in 1974.

Demand for home furnishings arises primarily from new family formations (which dictate initial purchases), from changes in residence and from wearing out or style obsolescence of existing furnishings. The declining birthrate and the trend to smaller sized homes tend to slow down the growth rate.

(c) Other Consumer Products. Other consumer products are piece goods for home sewing, craft and handwork yarns, medical, surgical and sanitary products and toy fabrics. These products account for 11 per cent of textiles production. Steady growth in these areas is to be expected.

(d) Industrial Products. Industrial fabrics make up 17 per cent of the textile output in the U.S., and growth has been experienced in a number of these specialized markets, such as transportation fabrics, hose and belting, filtration, coated and protective fabrics, industrial sewing thread and glass-fiber fabrics for reinforced plastics. The potential for further growth is good and can be greatly augmented by development of new products.

2.2.2 Raw Material and Fabric Usage in the Industry

Fiber is the basic raw material in the manufacture of textile products. Approximately 70 per cent of the fibers used in U.S. mills in 1974 were man-made with the use of cotton diminishing drastically to approximately 29 per cent in 1974. Wool is of small significance, accounting for less than 1 per cent usage in 1974.

Woven fabrics form the largest segment of the textile industry, however, woven goods production has been dropping steadily since 1965. The 1974 production is only 80 per cent of 1965's peak production. The decline has come totally in cotton woven goods, with the 1974 production being approximately half of that of 1965. Woven fabrics of man-made fibers actually increased about 50 per cent during this period, but the increase was not sufficient to offset overall the decline in woven cotton goods production.

The knitting segment has been growing in importance. Knit cloth shipments nearly doubled between 1966 and 1973. A major portion of this growth was due to the introduction and popularization of double-knit fabrics. In 1967, it was estimated that there were 4,600 double-knit machines in use. By 1971, there were 16,000 and in 1973, there were 23,275, resulting in overexpansion and subsequent withdrawal and mothballing.

Another segment of the textiles industry that expanded substantially was carpets and rugs. From 1966 to 1973, shipments in this segment increased by almost 120 per cent. In 1974 there was a slight drop-off. More recently some mills abandoned such operations, suggesting again overexpansion and overcapacity.

Man-made fibers, especially the newer ones, have excellent uniformity and are available in a growing variety of types. They offer a higher degree of processing efficiency. In addition, there is a much smaller inventory risk, as compared with natural fibers. The wide and erratic price fluctuations of cotton and wool sometimes make carrying inventories almost a wild speculation.

Man-made fibers are further classified into non-cellulosic and cellulosic. The non-cellulosic fibers have attained a position of dominance, accounting for about 85 per cent of the production of man-made fibers. These non-cellulosic fibers, sometimes called chemical fibers, are essentially extruded filaments of compounds such as polyester, nylon, polyethylene, polypropylene, acrylics and glass. Of these, polyester is in greatest demand, and accounts for about 42 per cent of the non-cellulosic fibers produced. Nylon ranks next in importance and accounts for 31 per cent of production. Glass fiber is the major inorganic chemical fiber used in textiles, accounting for 9 1/2 per cent of production; its use is rising sharply, both in industrial applications in home furnishings, where its fire retardant properties have helped in opening additional markets.

Other man-made fibers are derived from cellulose. Examples are rayon (regenerated cellulose), acetate (cellulose acetate), and triacetate (cellulose triacetate). This class of fibers constitutes only 15 per cent of the man-made fibers or about 11 per cent of the total fibers used in the U.S. Cellulosic fibers use has been adversely affected by the shift in popularity to the non-cellulosic fibers. Since 1970, both use and production capacity have decreased markedly.

Cotton has been of diminishing importance as a textile raw material. It comprised 88 per cent of the fiber used in textiles in the 1920's. By 1960 it was 64%, and by 1974 it had dropped to a new low of 29 per cent. In 1975, its use is expected to decrease even more. Price and consumption support plans of the Federal Government may have contributed to pricing cotton out of the market in its competition with synthetic fibers.

2.2.3 Current Economic Structure

Since 1970, a considerable shift of assets has taken place in the textiles industry. Plants which gave low returns on investments or offered poor prospects for growth were closed, while new capital investments were made in areas promising better growth prospects and therefore possibly better returns on investment.

The return on investment in the textiles industry has always compared unfavorably with investments in other industries, generally being approximately one-third less than the average for all manufacturing companies. Under adverse economic conditions the comparison is even worse; for instance, in 1970 the ratio of returns dropped to only 55 per cent.

Capital expenditures increased from $560 million in 1970 to $840 million in 1974, but the increase was superficial rather than real, because inflation was responsible for most of the money spent. Furthermore, the expenditure was for substitution of newer and more efficient equipment, so that there were few actual physical additions in production units.

The reduced pace of earnings since 1974 have prompted efforts to improve the financial structure in the industry. Tighter controls to reduce inventories and receivables, cuts in dividends to stockholders and downward revisions of capital expenditures have been instituted. Capital expenditures were expected to decline to $700 million in 1975, partly because of the overexpansion of the last few years. Further reduction in capital expenditures is likely in the future, with a growing portion of the capital expenditures to be earmarked for equipment or programs to comply with new Government health and environmental legislation.

Raising the funds for capital expenditures will present the industry with a dilemma. Raising money by equity financing (selling stock to the public) is unpalatable, as the stocks of most textile companies are selling at substantial discounts from book value. Growing companies may finance their capital needs by increasing long-term borrowing, but the prevailing high interest rates make this method expensive and ultimately result in lower earnings. The smaller and more marginal companies may well find the problem very difficult to surmount.

The situation may become somewhat alleviated if demand for textiles resurges in the later months of 1975 as the economy improves as is expected and prices become firmer as inventory levels are worked down. If the economy continues to improve into 1976, stimulating a further increase in demand, then the efficiencies instituted in the last 2 years will result in a substantial improvement to the financial situation of the industry.

Profit margins,* as in the case of return on investment, are significantly lower in the textiles industry than for industry at large, averaging 10.8 per cent for the last 10 years. This figure is about 30 per cent less than the 15.5 per cent for industry at large.

In the textiles industry, material costs represent almost 60 per cent of the value of the product, and exert the greatest influence on profit margins. By far, the greatest portion of the material costs is accounted for by the fibers used. These wide swings in fiber prices have caused not only changes in cost, but also in inventory evaluations. It is the uncertainty of prices of the natural fibers that has accentuated the shift to the use of man-made fibers. The cost of chemicals and dyes has also increased sharply in recent years.

Labor is the second largest cost factor. Labor costs, however, vary widely with the nature of the products made, the production methods used, and also with the extent of automation and integration. According to the 1972 Census data, overall labor costs for the textiles industry were 21.6 per cent of the value of goods produced. However, the breakdown showed that labor costs were 27 per cent for cotton mills, 26 per cent for man-made fiber weaving mills and 17 per cent for knit fabric mills. One year later, in 1973, the labor costs of six leading integrated textile companies were reported to be about 30 per cent of sales.

Wage rates in the textiles industry are about 28.5 per cent lower than wage rates for all manufacturing companies. Nevertheless, the general rise in wage rates has caused labor costs to double in the last 15 years. To counter the uptrend, steps have been taken to modernize equipment, to eliminate less productive plants, and to put greater emphasis on higher priced products in the product mix.

Furthermore, management has turned to greater utilization of electronic data processing to supply useful and up-to-date information for decision making. The use of such specialized management techniques has permitted much better procurement control, production scheduling,

* Profit margin is defined as operating income before deducting depreciation and Federal taxes, divided by sales.

sales-to-inventory turnover ratio and improvement in warehousing and distribution costs.

Inventory control has historically been a major weakness in the textiles industry. The industry tended to overbuild inventories both in raw materials and finished products during periods of prosperity, gearing production to equipment capability rather than to actual orders or demand. The subsequent decrease in business activity would render such high inventory levels expensive to maintain because of finance charges. The problem was further aggravated by the drop in the value of raw materials and finished products during such slack periods. Often in the past, the companies had to cut back on their inventories of finished products at prices below cost. The use of electronic data processing appears to have improved inventory control considerably. Management has also put increased emphasis on consumer market studies and consumer testing of new lines.

2.2.4 Future Trends and Developments

Since 1970, the textiles industry has made substantial additions to its production capacity. Indeed this expanded capacity was heavily taxed in 1973, when mill operating rates rose to 90 per cent of capacity. The subsequent economic downturn of 1974-75 found the industry with a huge inventory and idled about one-third of production capacity. At this time, there appears to be sufficient capacity to meet market needs for several years to come.

During the recent expansion, quite aside from the growth in numbers of production units (cotton-weaving was the only sector showing a decline), there was a decided effort to replace older equipment with modern and more productive machines and to direct capital outlays into newer marketing areas such as for the production of double-knits and stretch-woven fabrics.

Over the next three years, no further increase in production units is expected. Capital expenditures were projected to be about $700 million for 1975, and $850 million for 1976. However, the American Textile Manufacturers Institute projected that for 1975-77, annual outlays of about $659 million would be required for equipment and programs to comply with Government health and environmental legislation. If this projection is even approximately accurate, very little funds will be left for plant modernization.

Raising the funds for capital expenditures will be somewhat of a problem for the industry. Equity financing by selling common stock is not advantageous because most textile stocks are selling at substantial discounts from book value. Long-term debt financing will saddle the industry with high interest charges. The smaller or marginal companies may find the problem especially difficult to surmount.

Raw material supplies should be more than adequate to meet expected needs and no shortages are expected. Production capacity of polyester, both in the U.S. and worldwide, is 25 per cent greater than usage even during the peak period in 1973, and even if there were no further increase, this capacity would be sufficient to meet demand for the next two years. Late in 1974, demand was so slack that prices weakened and only half the polyester producing capacity was utilized. Some upward revision in demand took place in 1975, but supplies are still excessive and will probably remain so for the next two years.

Nylon production capacity similarly has outstripped production needs, and nylon is now also in excess supply.

Cotton is declining in importance as a textile fiber and sharp drops in its use are expected. Nevertheless, production will continue to be excessive, and carryover stocks are increasing both in the U.S. and worldwide. Thus, supplies are more than adequate to meet expected needs. The textile industry, therefore, can expect price stability in its major raw materials for the next two years.

Labor cost, the industry's second largest cost factor, is expected to continue its uptrend. Since wage rates are lower than those prevalent in industry at large, wages are expected to move closer to the higher average rates. Additional upward pressure is to be expected if domestic or worldwide inflation persists.

Management, for its part, has adopted more sophisticated techniques to improve its performance. It has made greater use of electronic data processing to control procurement, production and inventory. It has also changed from its former practice of gearing production to equipment capacity, and now attempts to match production to the demands of the marketplace. Increased emphasis has been placed on consumer market studies and consumer testing of new lines as guides to production planning and to development of new markets. The benefits of these measures will become more evident with improvement in market conditions.

The economy was expected to and did begin recovery in the second half of 1975 and continue to improve into 1976. Demand for textile products should keep pace with the recovery as more disposable income becomes available. The higher level of business activity coupled with the recent cost-cutting measures and stable raw material prices should enhance the profitability of the textile companies.

The export markets may offer another area of improvement. For many years, world prices were considerably lower than domestic prices. Recently, exports have risen sharply as domestic prices have moved closer to world prices. The devaluation of the dollar, the rapid advances in labor costs abroad, the greater efficiency of domestic plants, and the development of newer products by U.S. companies have all contributed to the export surge. These same reasons and the reduction in delivery lead time will also make domestic products more competitive with imported textiles.

2.3 Industry Characterization

Industry characterization is concerned with the categorization of the industry by products manufactured, processes used, or any other viable method to determine the distribution of the number of plants in each industry category, the distribution of plants by size (number of employees), the distribution of plants by age of processing equipment, the distribution by manufacturing processes and the distribution of production in each industry category.

This task was accomplished by utilizing various sources of data as well as information obtained from trade associations and plant visits. The major efforts in this phase were directed toward collecting information on the distribution of the number of plants and the distribution of production of the plants in the industry categories that generate potentially hazardous wastes destined for land disposal since this information was required to accomplish the other three phases of the study (Phase II - Waste Characterization, Phase III - Treatment/Disposal Technology, and Phase IV - Cost Analysis).

2.3.1 Rationale for Industry Categorization

Initial attempts to categorize the textiles industry by four-digit Standard Industrial Classification (SIC) codes proved to be an inadequate method for the purposes of this study. Reasons for this are:

a. The SIC code method of classifying the industry is obsolete. For example, SIC 2261 is the dyeing and finishing of woven cotton broadcloth and SIC 2262 is the dyeing and finishing of woven man-made fiber broadcloth. Very few plants in the industry are devoted to either 100 per cent cotton of 100 per cent man-made fiber cloth. Most plants are producing cloth with blends of fibers and there is no SIC code for this type of plant. This is also true in SIC 2231 (woven wool fabrics) where very few plants are producing 100 per cent wool fabrics.

b. The SIC code method of classification includes all plants in the group. For example, SIC 225 includes all knitting plants and SIC 227 includes all carpet plants. This study is concerned only with those plants that perform dyeing and finishing operations. These operations are the direct or indirect source of potentially hazardous land-destined wastes. The exception to this is Wool Scouring which is part of SIC 2299. Sludges generated by Wool Scouring wastewater treatment plants were found to contain heavy metals and chlorinated organics (see Section 3 of this report).

The SIC code method of categorizing the textiles industry was also found inadequate by another EPA contractor (Arthur D. Little, Inc.) during their development of the effluent limitations guidelines for the textiles industry. Versar and the American Textile Manufacturers Institute (ATMI) agreed that the best method for categorizing the industry for this study was by process and not by product. Therefore, the method used by Versar is the same as was ultimately used in the effluent limitations guidelines document and is as follows:

Category	Process	SIC Groups Included
A	Wool Scouring	2299
B	Wool Fabric Dyeing and Finishing	2231
C	Greige Goods	2211, 2221, 2231, 2241, 2251, 2252, 2253, 2254, 2257, 2258, 2259, 2281, 2282, 2283, 2284
D	Woven Fabric Dyeing and Finishing	2261, 2262
E	Knit Fabric Dyeing and Finishing	2251, 2252, 2253, 2255, 2257, 2258, 2259
F	Carpet Dyeing and Finishing	2272
G	Yarn and Stock Dyeing and Finishing	2269

2.3.2 Distribution of Plants by Number of Establishments

Table 2-1 shows the distribution of textile plants by industry category. The wet processing plants (plants that perform dyeing and/or finishing operations) listed are the ones which generate potentially hazardous wastes for land disposal. The 3,359 greige goods plants, Category C, do not generate potentially hazardous waste.

A total of 2,007 establishments that perform dyeing and/or finishing operations was identified. The breakdown of this part and the entire industry on an EPA Regional basis is as follows:

Table 2-1. Distribution of Textile Plants by Industry Category

		Industry Category							
		A	B	C	D	E	F	G	Total
IV	Alabama			47	20	20	2	8	97
X	Alaska								
IX	Arizona								
VI	Arkansas			11	1		2		14
IX	California		1	128	19	11	10	8	177
VIII	Colorado			4	2				6
I	Connecticut	1	4	31	18	5		6	65
III	Delaware			3	2				5
IV	Florida			91	7	9	1		108
IV	Georgia		5	266	41	35	91	41	479
IX	Hawaii								
X	Idaho			1		1			2
V	Illinois			46	8	4		8	66
V	Indiana			11	3		1		15
VII	Iowa		1	4		2			7
VII	Kansas			3	1				4
IV	Kentucky			8	3	6	2	2	21
VI	Louisiana			8		3			11
I	Maine		9	7	5	1		2	24
III	Maryland			11	5	1			17
I	Massachusetts	5	16	80	52	10	2	19	184
V	Michigan		2	19	2	1	1		25
V	Minnesota		1	17	1	5		1	25
IV	Mississippi			19	2	4			25
VII	Missouri			6	9			2	17
VIII	Montana			1					1
VII	Nebraska			7					7
IX	Nevada								
I	New Hampshire		6	10	5	5		5	31
II	New Jersey		11	294	79	39	1	28	452
VI	New Mexico			2					2
II	New York		10	684	88	71	3	37	893
IV	North Carolina		9	718	104	326	6	85	1,248
VIII	North Dakota								
V	Ohio		1	39	11	4	1	4	60
VI	Oklahoma			13	2	1	2	1	19
X	Oregon	1	4	14		1		1	21
III	Pennsylvania	1	10	334	43	62	5	32	487
I	Rhode Island	2	6	44	35	9		25	121
IV	South Carolina	2	4	177	49	31	6	18	287
VIII	South Dakota								
IV	Tennessee		1	93	10	36	4	8	152
VI	Texas	4	3	23	4	5	2		41
VIII	Utah		1	4			1		6
I	Vermont		2	7	2	1			12
III	Virginia	1	3	45	17	20	1	2	89
X	Washington		1	14					15
III	West Virginia			4		1			5
V	Wisconsin		1	11	1	8		2	23
VIII	Wyoming								
TOTAL		17	112	3,359	651	738	144	345	5,366
Region	I	8	43	179	117	31	2	57	437
	II		21	978	167	110	4	65	1,345
	III	2	13	397	67	84	6	34	603
	IV	2	19	1,419	236	467	112	162	2,417
	V		5	143	26	22	3	15	214
	VI	4	3	57	7	9	6	1	87
	VII		1	20	10	2		2	35
	VIII		1	9	2		1		13
	IX		1	128	19	11	10	8	177
	X	1	5	29		2		1	38

Key: A – Wool Scouring
B – Wool Fabric D&F
C – Greige Goods (Dry)
D – Woven Fabric D&F
E – Knit Fabric D&F
F – Carpet D&F
G – Yarn and Stock D&F

EPA Region	Entire Industry No. of Plants	Entire Industry Percentage of Total	Plants Performing Dyeing and Finishing Operations No. of Plants	Plants Performing Dyeing and Finishing Operations Percentage of Total
I	437	8.1	258	13.0
II	1,345	25.1	367	18.0
III	603	11.2	206	10.0
IV	2,417	45.1	998	50.0
V	214	4.0	71	3.8
VI	87	1.6	30	1.5
VII	35	0.7	15	0.7
VIII	13	0.2	4	0.2
IX	177	3.3	49	2.4
X	38	0.7	9	0.4
	5,366	100	2,007	100

As shown in this breakdown, ninety-one per cent of the plants that generate potentially hazardous wastes are located in EPA Regions I, II, III and IV with fifty per cent located in Region IV alone. Also, the textiles industry as a whole is heavily concentrated in the eastern part of the U.S.

The 2,007 plants of concern to this study are approximately 37 per cent of the total number of textile operations in the U.S. (10). The remaining 63 per cent are dry operations and do not generate potentially hazardous land-destined wastes.

2.3.3 Distribution of Plants by Size (Number of Employees)

Table 2-2 shows the distribution of the textile plants with respect to their size (number of employees) (4), (5), (6), (7). Data for the plants listed in the "unknown" column were not available.

The distribution of the plants in the various size ranges is as follows:

Size Range (No. of Employees)	Number of Plants in Range	Percentage of Total Plants
1-4	103	1.9
5-9	144	2.7
10-19	242	4.5
20-49	653	12.2
50-99	614	11.4
100-249	991	18.5
250-499	602	11.2
500-999	377	7.0
1,000-2,499	159	3.0
over 2,500	37	0.7
unknown	1,444	26.9
Totals	5,366	100

Table 2-2. Distribution of Textile Plants by Size (Number of Employees)

		Number of Employees											
		Unknown*	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000-2499	> 2500	Total
IV	Alabama	41			2	2	8	13	10	13	6	2	97
X	Alaska												
IX	Arizona												
VI	Arkansas							14					14
IX	California	36		12	18	25	36	25	14	7		4	177
VIII	Colorado		3			3							6
I	Connecticut	17		2		6	6	15	13	4	2		65
III	Delaware					3			2				5
IV	Florida	32	6		6	13	13	13	25				108
IV	Georgia	115	13	7	23	43	56	101	22	49	13	7	479
IX	Hawaii												
X	Idaho	2											2
V	Illinois	20		3		13	10	7	10	3			66
V	Indiana	7						4	4				15
VII	Iowa							7					7
VII	Kansas				4								4
IV	Kentucky	6			2	2	2	7		2			21
VI	Louisiana							4	4		3		11
I	Maine	6					4	3	6	4	1		24
III	Maryland	6				2		9					17
I	Massachusetts	55	2	5	5	21	25	34	27	7	3		184
V	Michigan							9					25
V	Minnesota	6				6		9				4	25
IV	Mississippi	13					4		4		4		25
VII	Missouri	6		2		4	3			2			17
VIII	Montana							1					1
VII	Nebraska							7					7
IX	Nevada												
I	New Hampshire	6			3	2	2	6	10	1	1		31
II	New Jersey	10	11	20	31	94	69	80	20	20			452
VI	New Mexico							2					2
II	New York	269	38	21	60	162	90	141	68	22	22		893
IV	North Carolina	309	9	28	47	129	139	234	168	138	45	2	1,248
VIII	North Dakota												
V	Ohio	11	3	6	6	3	3	9	13	6			60
VI	Oklahoma				3			16					19
X	Oregon	3					12	3				3	21
III	Pennsylvania	134	9	29	26	54	66	92	39	16	22		487
I	Rhode Island	22	6		3	28	13	25	19	5			121
IV	South Carolina	112	3	3		5	18	39	39	48	10	10	287
VIII	South Dakota												
IV	Tennessee	39			3	13	21	23	26	9	15	3	152
VI	Texas	21				7	2	9		2			41
VIII	Utah	3				3							6
I	Vermont	2					2	8					12
III	Virginia	26		2		5	6	18	12	6	12	2	89
X	Washington								15				15
III	West Virginia									5			5
V	Wisconsin	4		4		5	4	4	2				23
VIII	Wyoming												
TOTAL		1,444	103	144	242	653	614	991	602	377	159	37	5,366
Region	I	108	8	7	11	57	52	91	75	21	7		437
	II	376	49	41	91	256	159	221	88	42	22		1,345
	III	166	9	31	26	64	72	119	53	27	34	2	603
	IV	667	31	34	83	207	261	430	324	259	93	24	2,417
	V	56	3	13	6	21	17	42	29	17		4	214
	VI	21			3	7	2	45	4	2	3		37
	VII	6		2	4	4	3	14		2			35
	VIII	3	3			6		1					13
	IX	36		12	18	25	36	25	14	7		4	177
	X	5					12	3	15			3	38

*No data could be found concerning the size of these plants (number of employees).

Of the plants with known sizes, the facilities which employ between 100-249 workers are the most numerous. Plants having size ranges of 20-49, 50-99 and 250-499 are the next largest with respect to the number of employees and are about equal in magnitude. Together these four groups contain over 53 per cent of the plants. It is probable that many of the plants in the "unknown" column would also fall into these four size groups.

2.3.4 Distribution of Plants by Age

Table 2-3 shows the distribution of production equipment by age for the plants visited by industry category. Process equipment age data was not available in the literature and the extrapolation of the data in Table 2-3 to the entire industry would be meaningless. However, process equipment age was not considered to be a determining factor in the generation of potentially hazardous waste destined for land disposal.

The following data summarizes the ages of the process equipment at the plants visited in each category:

	(No.) and Percentage of Plants in Age Range		
Category	less than 5 years	5-20 years	more than 20 years
A - Wool Scouring		(2) 50	(2) 50
B - Wool Fabric Dyeing and Finishing		(1) 14	(6) 86
C - Greige Goods	(1) 20	(3) 60	(1) 20
D - Woven Fabric Dyeing and Finishing		(10) 45	(12) 55
E - Knit Fabric Dyeing and Finishing	(4) 20	(10) 50	(6) 30
F - Carpet Dyeing and Finishing	(1) 9	(8) 73	(2) 18
G - Yarn and Stock Dyeing and Finishing	(1) 9	(1) 9	(9) 82
Totals	(7)	(35)	(38)

Of the plants visited, 47.5 per cent had process equipment with ages over 20 years, 43.8 per cent with ages from 5-20 years and 8.7 per cent with ages less than 5 years. These percentages would most likely be representative of the industry as a whole.

2.3.5 Distribution of Plants by Process

Because the industry was categorized on a process oriented basis rather than a product oriented basis, Table 2-1, distribution of the number of establishments by industry category, also shows the distribution of the plants by process. The following summarizes the process distribution:

Table 2-3. Distribution of Production Equipment by Age for Plants Visited by Industry Category

		A-Wool Scouring				B - Wool Fabric D & F				C-Greige Goods				D-Woven Fabric D & F				E-Knit Fabric D & F				F-Carpet D & F				G-Yarn and Stock D & F				Total Visited
		1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	1	2	3	T	
IV	Alabama											1	1		2	1	3			1	1		1		1			1	1	7
X	Alaska																													
IX	Arizona																													
VI	Arkansas																													
IX	California																						2		2					2
VIII	Colorado																													
I	Connecticut																											1	1	1
III	Delaware																													
IV	Florida																													
IV	Georgia							1	1		1		1		2	3	5					1	4	1	6	1	1	2	4	17
IX	Hawaii																													
X	Idaho																													
V	Illinois																													
V	Indiana																													
VII	Iowa																													
VII	Kansas																													
IV	Kentucky																													
VI	Louisiana																													
I	Maine						1	2	3																					3
III	Maryland																													
I	Massachusetts			1	1			1	1							1	1			1	1									4
V	Michigan																													
V	Minnesota																													
IV	Mississippi																													
VII	Missouri																													
VIII	Montana																													
VII	Nebraska																													
IX	Nevada																													
I	New Hampshire							2	2																					2
II	New Jersey																													
VI	New Mexico																													
II	New York																			1	1									1
IV	North Carolina										1		1		2	2	4		6		6		1		1			2	2	14
VIII	North Dakota																													
V	Ohio																													
VI	Oklahoma																													
X	Oregon																													
III	Pennsylvania																			1	1									1
I	Rhode Island														1	1	2													2
IV	South Carolina		1	1	2					1	1		2		3	3	6	3	4	1	8			1	1			2	2	21
VIII	South Dakota																													
IV	Tennessee																			1	1							1	1	2
VI	Texas																													
VIII	Utah																													
I	Vermont																													
III	Virginia		1		1											1	1	1			1									3
X	Washington																													
III	West Virginia																													
V	Wisconsin																													
VIII	Wyoming																													
TOTAL			2	2	4		1	6	7	1	3	1	5		10	12	22	4	10	6	20	1	8	2	11	1	1	9	11	80
Region I				1	1		1	5	6						1	2	3			1	1							1	1	12
II																				1	1									1
III			1		1											1	1	1		1	2									4
IV			1	1	2			1	1	1	3	1	5		9	9	18	3	10	3	16	1	6	2	9	1	1	8	10	61
V																														
VI																														
VII																														
VIII																														
IX																							2		2					2
X																														

Key: 1 - less than 5 years
2 - 5-20 years
3 - more than 20 years
T - Total

Process	No. of Plants	Percentage of Total
Wool Scouring	17	0.3
Wool Fabric Dyeing and Finishing	112	2.1
Greige Goods	3,359	62.6
Woven Fabric Dyeing and Finishing	651	12.1
Knit Fabric Dyeing and Finishing	738	13.8
Carpet Dyeing and Finishing	144	2.7
Yarn and Stock Dyeing and Finishing	345	6.4
Totals	5,366	100

As shown in the above breakdown, over 62 per cent of the plants are engaged in greige goods manufacture which generates no potentially hazardous wastes. Of the remaining plants that perform dyeing and/or finishing operations, over 69 per cent are in the woven fabric and knit fabric dyeing and finishing categories.

2.3.6 Distribution of Plants by Production

Table 2-4 shows the estimated distribution of production by industry category. The methodology used to distribute the production on a state-by-state basis for the industry categories is as follows:

Category A - Wool Scouring

The total estimated annual production in this category, 69,000 kkg/year, was obtained by multiplying the average production rate of the four plants visited by the number of plants identified. Some of the state-by-state data was withheld because of the small number of plants in this category and the possibility of revealing proprietary production rate information.

Category B - Wool Fabric Dyeing and Finishing

The total estimated annual production in this category, 309,000 kkg/year, was obtained by multiplying the average production rate of the seven plants visited by the number of plants identified. The state-by-state distribution was obtained the same way.

Category C - Greige Goods

The total estimated annual production in this category is 3,000,000 kkg/year. This figure is based on information supplied by the ATMI. Production data distribution was estimated using 1972 Census of Manufactures data, Dun Market Indicator data and contractor judgment.

Table 2-4. Estimated Distribution of Production by Industry Category

Industry Category - Production Thousand Metric Tons/Year

		A	B	C	D	E	F	G	Total State
IV	Alabama			46	84	30	9	38	207
X	Alaska								
IX	Arizona								
VI	Arkansas			11	2		9		22
IX	California		3	127	2	11	81	38	262
VIII	Colorado			4	1				5
I	Connecticut	*	11	22	40	5		29	107+
III	Delaware			2	4				6
IV	Florida			90	15	10	4		119
IV	Georgia		14	263	170	36	409	197	1,089
IX	Hawaii								
X	Idaho			1		1			2
V	Illinois			45	45	4		38	132
V	Indiana			11	6		4		21
VII	Iowa		3	4		2			9
VII	Kansas			3	2				5
IV	Kentucky			8	6	6	9	10	39
VI	Louisiana			8		3			11
I	Maine		25	5	12	1		10	53
III	Maryland			8	10	1			19
I	Massachusetts	20	44	57	166	15	9	91	402
V	Michigan		5	19	4	1	4		33
V	Minnesota		3	17	2	5		5	32
IV	Mississippi			19	4	4			27
VII	Missouri			6	3			10	19
VIII	Montana			1					1
VII	Nebraska			7					7
IX	Nevada								
I	New Hampshire		16	7	11	5		24	63
II	New Jersey		30	210	154		4	135	573
VI	New Mexico			2					2
II	New York		28	489	60	70	13	178	838
IV	North Carolina		25	710	334	310	27	409	1,815
VIII	North Dakota								
V	Ohio		3	39	25	4	4	19	94
VI	Oklahoma			13	4	1	9	5	32
X	Oregon	*	11	14		1		5	31+
III	Pennsylvania	*	28	330	9	65	22	154	608+
I	Rhode Island	*	16	32	9	9		120	186+
IV	South Carolina	*	11	175	530	60	27	87	890+
VIII	South Dakota								
IV	Tennessee		3	90	20	38	18	38	207
VI	Texas	15	8	23	41	4	9		100
VIII	Utah		3	4			4		11
I	Vermont		5	5	4	1			15
III	Virginia	*	8	44	20	21	4	10	107+
X	Washington		3	14					17
III	West Virginia			4		1			5
V	Wisconsin		3	11	2	6		10	32
VIII	Wyoming								
TOTAL		69	309	3,000	1,801	771	679	1,660	8,289
Region	I	20+	117	128	242	36	9	274	826+
	II		58	699	214	110	17	313	1,411
	III	20	36	388	43	88	26	164	745+
	IV		53	1,401	1,163	494	503	779	4,393+
	V		14	142	84	20	12	72	344
	VI	15	8	57	47	8	27	5	167
	VII		3	20	5	2		10	40
	VIII		3	9	1		4		17
	IX		3	127	2	11	81	38	262
	X	*	14	29		2		5	50+

* Data withheld because of its proprietary nature.

Key: A - Wool Scouring
B - Wool Fabric D & F
C - Greige Goods
D - Woven Fabric D & F
E - Knit Fabric D & F
F - Carpet D & F
G - Yarn and Stock D & F

Category D - Woven Fabric Dyeing and Finishing

The total estimated annual production of 1,801,000 kkg/year was obtained from the 1972 Census of Manufactures. Values for some of the major producing states such as North Carolina, South Carolina, Georgia, Massachusetts, etc., were also obtained from Census data, however, for those states not included in the Census report, the production, after subtracting the known state productions from the total, was divided by the number of plants remaining to obtain an average production per plant. This value was then used to determine the production for those states not identified in the Census report.

Category E - Knit Fabric Dyeing and Finishing

Estimating the total annual production of dyed and finished knits from the Census data is extremely difficult if not impossible because of the way the information is reported. For example, hosiery is reported in thousand dozen pairs. The estimate of the total annual production, 771,000 kkg/year, is based on figures supplied by the ATMI and the assumption that the ratio of dyed and finished goods to greige goods is the same for knits as it is for wovens. The state-by-state distribution was based on contractor estimates made by using the data obtained from the visited plants and judgment as to whether the state totals were consistent with the gathered information and the number of plants identified in the state.

Category F - Carpet Dyeing and Finishing

The total estimated annual production for this category, 679,000 kkg/year, was obtained as follows:

$$877 \times 10^6 \times \frac{144}{381} \times \frac{4.5}{2000} \times 0.91 = 679{,}000 \text{ kkg}$$

where: 877×10^6 = square yards of carpet/year from 1972 Census of Manufactures

144 = number of carpet plants that dye and finish

381 = total number of carpet plants

4.5 = pounds per square yard of finished carpet (average value)

2000 = pounds per ton

0.91 = metric tons per ton

The state-by-state distribution was accomplished by attributing 12 per cent of the total production to California (an estimate obtained during a visit to a California carpet plant) and allocating the remainder on an average production per plant basis. This method is felt to be reasonably accurate because the production for the state of Georgia amounts to about 60 per cent of the total, as claimed by the Carpet and Rug Institute (CRI).

Category G - Yarn and Stock Dyeing and Finishing

Census data could not be used in this category because the Census report does not include data for captive products. Many integrated plants that dye and finish their own yarn and stock do not appear in the Census data. Therefore, the total annual production of 1,660,000 kkg/year was obtained by using a selected average of the 11 plants visited and multiplying by the total number of plants identified. The state-by-state distribution was done the same way.

In summary, a total of 8,289,000 kkg/year is produced by the textiles industry. Those categories that generate potentially hazardous land-destined wastes produce 5,289,000 kkg/year. The percentages of the total for each industry category are:

Industry Category	Annual Production Rate (kkg/year)	Percentage of Total Production
A - Wool Scouring	69,000	0.8
B - Wool Fabric Dyeing and Finishing	309,000	3.7
C - Greige Goods	3,000,000	36.2
D - Woven Fabric Dyeing and Finishing	1,801,000	21.8
E - Knit Fabric Dyeing and Finishing	771,000	9.3
F - Carpet Dyeing and Finishing	679,000	8.2
G - Yarn and Stock Dyeing and Finishing	1,660,000	20.0
Totals	8,289,000	100

Of the categories that generate potentially hazardous wastes, Woven Fabric Dyeing and Finishing and Yarn and Stock Dyeing and Finishing are the largest with respect to annual production and combined, amount to 41.8 per cent of the total production.

The EPA Regional distribution of the total production is:

EPA Region	kkg/year in Region	Percentage of Total Production
I	826,000 +	9.9 +
II	1,411,000	17.0
III	745,000 +	9.0 +
IV	4,393,000 +	53.0 +
V	344,000	4.2
VI	167,000	2.0
VII	40,000	0.5
VIII	17,000	0.2
IX	262,000	3.2
X	50,000 +	0.6 +

More than 53 per cent of the total production in the industry occurs in EPA Region IV alone. Approximately 90 per cent of all production occurs in EPA Regions I, II, III and IV.

3.0 WASTE CHARACTERIZATION *

3.1 Introduction

In this section, the processes, the wastes resulting from each process, and the quantity of total and potentially hazardous waste generated are described for each segment of the industry. Discussions of the criteria employed for the determination of potentially hazardous wastes and a general description of the waste sampling techniques and analytical methods used are also included. Finally, a rationale for the selection of waste streams for technology and cost analysis is presented as the final subdivision of the waste characterization section.

The flow diagrams accompanying the process and waste streams descriptions are presented in the following format:

Raw materials are on the left and products are on the right. Waste products, both solid and liquid, are projected downward.

All diagrams are based on 1,000 units of mass of the principal product. For clarity, several operations have, in some cases, been combined in one block. The diagrams reflect our technical judgment of typical or usual operations in the given industrial category, rather than those associated with a specific, identifiable plant. Production rates and other data for the assumed typical plant are given in the text accompanying each diagram. Descriptions of individual processing steps were kept as brief and as general as possible. The glossary (Appendix A) of this report addresses specific operations and serves as an excellent supplement to the reader who would like more detailed information on any given operation. Dyeing and printing operations are extensively described in the glossary.

3.2 Criteria for Determination of Potentially Hazardous Wastes

"Hazardous wastes" are defined as any wastes or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are: lethal, nondegradable, or persistent in nature; may be biologically magnified; or may otherwise cause or tend to cause detrimental cumulative effects (11).

Hazardous wastes include materials which are:

a. toxic or poisonous (producing injury or illness through ingestion, inhalation or absorption through any skin surface);

b. corrosive (destructive to living tissue);

c. irritants (induce local inflammatory reaction in living tissue);

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

d. strong sensitizers (cause hypersensitivity on living tissue through an allergic or photo-dynamic process);

e. flammable;

f. explosive (generate pressure through decomposition, heat or other means);

g. infectious (represent a potential source of the transmission of diseases to human domestic animals or wildlife);

h. radioactive;

i. carcinogenic (causes malignant tumors);

j. mutagenic (causes heritable genetic changes);

k. teratogenic (causes non-heritable genetic changes).

These wastes can take the form of solids, sludges, liquids or gases (12,13).

The criteria used to determine the hazardousness of heavy metals and total organics present in textile wastes are the U.S. Public Health Service 1962 drinking water standards. The limit for total organics is 0.7 mg/liter and contractor analytical results showed much greater amounts (as much as 500 mg/liter) in sampled sludges. The heavy metals of most concern in the textile industry include arsenic, cadmium, chromium, cobalt, copper, lead, mercury and zinc. The specific limits in drinking water range from 0.001 mg/liter for mercury to 5 mg/liter for zinc. The other limits are detailed in the table below.

Metal	Limit	Source
As	0.05 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
Ba	1.0 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
Cd	0.01 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
$Cr^{(+6)}$	0.05 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
Co	0.2 mg/liter	Criteria for agricultural waters (irrigation)
Cu	1.0 mg/liter	1962 Recommended drinking water standards, U.S. Public Health Service
Fe	0.3 mg/liter	1962 Recommended drinking water standards, U.S. Public Health Service
Pb	0.05 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
Mn	0.05 mg/liter	1962 Recommended drinking water standards, U.S. Public Health Service

Metal	Limit	Source
Hg	0.001 mg/liter	Tentative suggested limits of certain trace elements not included in drinking water standards, U.S. Public Health Service
Ni	0.5 mg/liter	Criteria for agricultural waters (irrigation)
Se	0.01 mg/liter	1962 Mandatory drinking water standards, U.S. Public Health Service
Zn	5 mg/liter	1962 Recommended drinking water standards, U.S. Public Health Service

The drinking water standards were chosen as the criteria for determining the hazardousness of textile wastes since the landfill is a common disposal site for these wastes and resultant leachate may contaminate an aquifer, the ground water, or surface water, and ultimately reach a drinking water supply.

The problem of hazardousness of dyestuffs is of major concern in the textiles industry.

Dyestuffs are complex organic compounds refractory (non-biodegradable) to conventional aerobic treatment systems. Some dyestuffs contain heavy metals, such as chromium, copper and zinc. Only about 50 per cent by weight of commercial dye is dyestuff. The remainder is usually a non-hazardous filler (such as sugar) and surfactant. The consumer has actively demanded brighter colors as well as better lightfastness and washfastness in fabrics. This has resulted in the various types of resistant dyes in the textiles industry today.

The major dye types used on different fibers and the amount of total dye use this represents is given below. (8)

Dye Types	Fiber Used On	Per Cent of Total Dye Use
Vat dyes	cotton, rayon, polyester/cotton	26%
Direct dyes	cotton, rayon, polyester/cotton, nylon/cotton	17%
Disperse dyes	acrylic, acetate, polyester, polyester/cotton, nylon	15%
Acid dyes	wool, nylon	10%
Sulfur dyes	cotton, rayon, polyester/cotton	10%
Basic (cationic) dyes	acrylic, polyester, polyester/cotton, nylon	6%
Azoic dyes	cotton, rayon	3%
Fiber reactive dyes	cotton	1%
Fluorescent dyes	cotton, wool, rayon, polyester/cotton	1%

Dye Types	Fiber Used On		Per Cent of Total Dye Use
Mordant dyes	wool		1%
Aniline black dyes	cotton)		
Developed dyes	cotton, rayon)		
Dye blends	polyester/cotton)	Totals	
Indigo dyes	cotton, nylon/cotton)	approximately	10%
Natural dyes	cotton)		
Oxidation base dyes	cotton)		
			100%

As consumer demands shift toward greater use of synthetic fibers, percentages should shift toward greater use of disperse, direct and basic dyes. However, as more information becomes available on the nature of the environmental hazards posed by various dye types, it is possible that these percentages will shift to vat dyes and perhaps of necessity to new dye types not yet developed.

Although pollution resulting from dye process effluents is highly visible, the toxicity of dye wastes has largely been ignored until recently. The American Dye Manufacturers Institute (ADMI), beginning in 1971, sponsored several studies to evaluate the toxicity of a broad spectrum of dyes on fish and algae; to evaluate dye biodegradability and effect on aerobic and anaerobic processes; and to evaluate dye and non-dye sources of heavy metals in textile effluents.

Dyes derive their color from electron transitions between various orbitals. All organic compounds absorb light energy, but in an unsaturated system, the electrons are more mobile and resonance will cause absorption of the lower energy light in the visible range. Certain groups of atoms are associated with color and are called chromophores: C-C, C-O, C-S, C-N, N-N, N-O, and NO_2. However, colored molecules (chromogens) are not dyes unless they contain auxochromes such as NH_2, $NH(CH_3)$, $N(CH_3)_2$, and OH, which enable the molecule to dissociate electrolytically for binding with a substrate. Auxochromes may or may not alter the color of a dye.

One of the problems encountered in trying to assess the toxicity of dyes is that toxicity analogies between known structures and dyes fall short. A simple change in the location of an auxochrome, chromophore or other substituent may alter the toxicity of a dye drastically. Also, many dyes are heterocyclic compounds and exhibit chelating action. Therefore, toxicity could result either by the removal of metals essential to the environment or by synergistic action to increase the toxic effects of metals normally present.

The observations from the ADMI sponsored fish bioassay study of 46 dyes include the following: (16)

- none of the direct or vat dyes were toxic and most disperse dyes were not toxic.

- mordant black 11 and acid black 52, similar in structure, had similar *TL_{50} values (6 and 7 mg/liter, respectively).

- triphenylmethane dyes were the most toxic with the triaminophenylmethane, basic violet 1, toxic at lower concentration than was the diaminophenylmethane, basic green 4.

- in diaminoanthraquinone dyes the degree of toxicity appeared to be directly related to the amount of substitution.

- pH may affect toxicity by influencing the degree of ionization of the dye and the degree of ionization of its site of action on a test organism.

Of the 46 dyes studied, 13 had *TL_{50} values less than 50 mg/liter, with 10 of these dyes at less than 10 mg/liter. From a dye class standpoint, the basic dyes appear to be the most toxic due to their cationic nature. Cationics such as malachite green have long been known for their therapeutic fungicidal effects and bacteriostatic and amebicidic activity. (16, p. 11)

The direct and vat dyes were in all cases found to be non-hazardous. However, the disperse and acid dyes had a few exceptions:

Dye Name	TL_{50}
disperse blue 3	1 mg/liter
disperse blue 7	52 mg/liter
acid black 52	7 mg/liter
acid yellow 38	23 mg/liter
acid blue 113	4 mg/liter
acid green 25	1 mg/liter
acid blue 25	6.2 mg/liter
acid yellow 151	29 mg/liter

A similar bioassay study of algae was undertaken (17) on the 46 dyes previously studied along with 10 additional basic dyes since these showed the most toxic effects in the fish bioassays. The results showed a strong correlation with the effects on fish. The basic (cationic) dyes inhibited algal growth by more than 80 per cent at 1 mg/liter. Mordant black 11 and disperse blue 7 also showed these results.

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*TL_{50} values are concentration values of the dyes in the experimental water environment at which 50 per cent of the fish survived.

A study of the effect of biological treatment on nine dyes shown to be toxic to fish (18) concluded that none of the dyes seriously interfered with the reduction of BOD. Some of the dyes did inhibit nitrification (oxidation of ammonia to nitrate) and this could reduce the effectiveness of a biological treatment system. While the dyes tested did not seriously interfere with conventional biological treatment, this treatment was not adequate for removal of color or toxicity due to the presence of dyes.

Other ADMI sponsored studies included investigation of the effect of dyes on both aerobic (19) and anaerobic systems (15). In an aerobic system, 17 of the 46 dyes tested were inhibitory; however, some of these dyes became non-inhibitory after microbial acclimation. In the anaerobic process studies, two of the dyes (both anthraquinones) caused complete process failure by inhibiting methane fermentation. Two other dyes had initial inhibitory effects which were overcome by acclimation. The dyes also showed varying amounts of decolorization possibly due to physical adsorption onto the sludge, reduction reactions, microbial activity or various combinations of all three.

Thus while data on human toxicity is not available, the various studies sponsored by the ADMI on fish and algal toxicity do indicate that the basic (cationic) dyes and some acid and disperse dyes do warrant the label "potentially hazardous." Various thesis studies done at the Georgia Institute of Technology also serve to show the refractory nature of such dye types as anthraquinone disperse dyes (20), vinyl sulfone reactive dyes (21), and azo disperse dyes (22) in waste treatment systems. The conclusion to be drawn from these various sources are that dyes are essentially non-biodegradable given the aeration and retention time in a conventional waste treatment facility. There is no indication from these studies of how these dyes might react in a landfill. In fact, they may be subject to anaerobic degradation. This gives rise to another problem concerning the nature of dye metabolites which may arise from dye degradation.

In the ADMI sponsored study of anaerobic processes (15), it was found that many of the dyes appeared to have been decolored or altered (in visible spectra) during the anaerobic digestion process. Only 4 of the 46 dyes tested showed no signs of decolorization. The extent of degradation was not studied, but the various possible mechanisms of decolorization were discussed. A sanitary landfill is subject to anaerobic digestion and, therefore, the possibility of degradation of dyes present in landfilled sludges exists. Industry contacts indicated that a number of dyes such as acid blue 113, acid red 85, and direct blue 2 have carcinogenic intermediates. Acid blue 113 requires the use of alpha naphthylamine as a synthesis intermediate, and acid red 85 and direct blue 2 are both benzidene-based colors. While studies (15) indicate possible anaerobic digestion of dyes in landfilled textile sludges, they provide no knowledge of the nature of any metabolites resulting from the dye degradation. It is obvious that much work is needed to confirm anaerobic digestion of dyes and to characterize resultant dye metabolites for toxicity and/or carcinogenicity. However, until such studies are initiated and completed, the contractor believes the question of dye degradation under anaerobic landfill conditions and resultant metabolites indicates the necessity of labeling dye-containing waste streams "potentially hazardous."

A large variety of chemically complex dyes are used in mills where textile products are dyed. On an industry-wide basis, it is a virtually insurmountable task to trace the uses and fates of those dyes shown by the ADMI studies to be toxic. To further illustrate the complexity of the problem and the lack of data, only 56 of the more than 1,000 dyes commercially available were tested. It is more than likely that many more dyes could also prove toxic if additional bioassay studies were done. However, since 30 per cent of the dyes tested proved to have appreciable toxicities to fish and/or algae, and since knowledge on human toxicity is almost totally lacking in this area, it is felt that dye-containing waste streams are potentially hazardous.

In summary, basic (cationic) dyes, some acid dyes, and some disperse dyes have been shown to be toxic to fish and algae in bioassay studies, and therefore, are considered potentially hazardous. The remaining dye types are refractory organics which may degrade in an anaerobic atmosphere such as a landfill and leach out possible carcinogenic metabolites. For these reasons, all dye-containing waste streams are to be considered potentially hazardous.

Heavy metals are recognized as potential toxicants, depending on their concentration and chemical form in the environment. Metals which are most likely to be present in textile wastes and which have been cited as cause for concern (23) include:

Metal	Range of Metal Concentrations, ppm	Dye Type with Highest Metal Content
Arsenic	<1 to 1.4	fiber reactive
Cadmium	<1	all types
Chromium	3 to 83	vat
Cobalt	<1 to 3.2	acid
Copper	33 to 110	vat
Lead	6 to 52	fiber reactive
Mercury	0.5 to 1	vat
Zinc	3 to 32	basic

These metals are contained in premetallized dyes (3-4 per cent metal content) and some basic dyes requiring preparation as a double salt of zinc (3 per cent metal content), dichromates used to oxidize and fix certain dyes; chromium compounds used in topchroming; various metal salts such as $Zn(NO_3)_2$ used as catalysts for the application of wash-and-wear, durable press and water repellent finishes; heavy metal compounds used to improve washfastness or lightfastness in certain fabrics; metals used in flame retardant finishes; and metals entering a mill on fabrics and fibers also from application of pesticides or other chemicals.

In all cases where limits have been recommended for amounts of heavy metals in drinking water, these limits are used to define a substance as hazardous. The 1962 mandatory and recommended drinking water standard limits of the U.S. Public Health Service were chosen because of the possibility of leachate from textile sludges in a landfill contaminating an aquifer or groundwater and ultimately reaching a drinking water supply. In the case of Co and Ni, no drinking water standards have been recommended. The limits used for Co and Ni were found in the Criteria for Agricultural Waters (Irrigation). The Hg limit selected is one of the tentative limits suggested by the U.S. Public Health Service for certain trace elements not included in the drinking water standards.

The other hazardous components of textile wastes includes some of the many chemicals used in dyeing and finishing operations, such as acids, alkalies, bleaches, adhesives and polymers, cross-linking agents, carbonizing agents (wool), conditioners, catalysts, detergents, dye carriers, chemical finishes (including flame retardants) and solvents. See Appendix D for a partial listing of the chemicals most used in the textile industry. The chemicals most likely to be potentially hazardous are the dye carriers, solvents, and chemical finishes. Dye carriers are organic compounds such as biphenyl, orthophenylphenol, butyl benzoate, methyl salicylate, trichlorobenzene, perchloroethylene, and other chlorinated aromatics, which accelerate the absorption of dyes by the fibers in a dye bath. A study (24) of the biodegradability of some dye carriers in activated sludge waste treatment systems showed the carriers used most heavily in the textiles industry today to be resistant to conventional waste treatment systems. Therefore, these dye carriers could be expected to persist in the environment. Also certain of the carriers such as biphenyl, toluene, naphthalene were considered toxic to the biota of the aeration basin in which they were tested for degradation.

The remainder of the chemicals used in the textiles industry (estimated to be 75 per cent by weight) are non-hazardous materials such as common salt and sodium sulfate. This estimate was based on information from industry contacts.

The criteria for considering textile processing chemicals hazardous includes the drinking water limits for the various heavy metals contained in some of the salts and the limit for total organics (0.7 mg/liter) in drinking water. The criteria applied for determining the hazardousness of flammable solvents and still bottom wastes is the Department of Transportation's Flashpoint Standard of 38 C (100 F) (25). We consider these to be potentially hazardous if the solvent constituent has a flashpoint below the DOT standard.

Some of the solvents used include:

Solvents	Flashpoints, C	(F)
Acetone	- 9	(15)
Methanol	18	(65)
Naphtha	- 7 to 43	(20 to 110)
Trichloroethane		none
Dioxane	18	(65)
Butyl Carbitol	115	(240)
Butyl Cellosolve	74	(165)

3.3 Discussion of Sampling Techniques and Analytical Methods Used

Sampling of a representative number of dyeing and finishing mills in each subcategory, except C, Greige Goods, was carried out during this program. The plants chosen were those deemed representative of a certain subcategory in terms of processing and fiber types used.

Four-hour composite sludge samples from textile mill wastewater treatment facilities were collected from the clarifier underflow returning to the aeration pond. Two separate sets of samples were taken, one for heavy metal analyses and one for chlorinated organic analyses. Sampling was repeated at each plant once a week for four consecutive weeks.

Samples earmarked for heavy metal analysis were put in plastic bottles and acidified with nitric acid to a pH of 2. The samples for organics analysis were not acidified and were handled carefully to avoid contamination.

The textile sludges had solids contents of 2 per cent or less and therefore, the atomic absorption method for determining total trace metals was used. The solids content of the textile sludges was determined by total evaporation of a volume of unpreserved sample and drying to a constant weight. Details of this and other analytical methods used can be found in Appendix C.

For atomic absorption analysis, the sludge samples were digested using heat and acid addition, the residue redissolved in acid and sample volume adjusted with distilled water. The samples were then filtered to remove insoluble materials, and aspirated directly into the flame source. The absorbence was recorded and the corresponding metal concentration determined.

Alternate methods were used to determine mercury and arsenic concentrations. Mercury concentration was measured by the flameless atomic absorption method using a quartz lamp as the radiation source to vaporize the mercury. Arsenic was determined either by atomic absorption or by the silver diethyldithiocarbamate method (see Appendix C).

Trace amounts of metals in the suspended solids portion of the non-acidified sludge samples were measured by centrifuging a sample, drying and digesting the solids and then using the atomic absorption method as mentioned above.

The suspended solids in the sludge samples were determined by filtering, drying and weighing a known volume of the sample.

The chlorinated organics were determined from the non-acidified sludge samples by gas chromatography. The samples were prepared by adjusting the pH to 6.5-7.5, extracting with methylene chloride in hexane, concentrating the extract on an evaporating hot water bath and injecting the extract into the gas chromatograph. The concentration of chlorinated organics was then calculated.

3.4 Characterization of Waste Types by Industry Categories

The method used to extrapolate waste quantities to the entire industry category is the same in all categories that generate potentially hazardous wastes. Therefore, to avoid repetition in each category's discussion of waste quantities, the extrapolation method used is given below.

Waste quantities were keyed to the production rates. The waste generation factors (kg of waste/metric ton of product) identified in Figures 3-1 through 3-7, were applied to production figures to yield state-by-state quantities of total wastes, container wastes and wasted sludge.

Through discussions with industry representations, the contractor has estimated that only 25 per cent of the chemicals used in dyeing and finishing operations should be considered potentially hazardous. This figure was used in the estimation of hazardous constituents in the chemical container waste streams.

Retained sludge quantities were established using the following equation:

$$\frac{V}{P} \times SS \times SRP = DSR$$

Where:

$\frac{V}{P}$ = Average ratio of wastewater aeration basin volume* to production of the direct discharge plant*

SS = Per cent suspended solids** divided by 100

SRP = State or regional production attributed to direct discharge plants

DSR = Total amount of dry solids retained in any given state
or region

* Data acquired by plant visits
** Data acquired by laboratory analysis

Once the dry retained sludge quantities were identified, the total heavy metal and total chlorinated organics concentrations were multiplied by the sludge quantities to determine state or EPA regional distributions of these hazardous constituents. Wet retained sludge quantities were calculated from the dry amounts using per cent suspended solids measurements determined by laboratory sludge analysis.

Dyestuff quantities in the sludge were estimated by the contractor to be approximately 5 per cent of the dry weight of the sludge.

Descriptions of typical processes employed and wastes generated by each category of the textiles industry are given below. The reader should be aware that while data in the state-by-state distribution of the tables are expressed in two significant figures, they are displayed in this manner simply to have the columns total properly. Data in the "Total" and "Region Total" sections may be expressed in three or more digits. It should not be construed that these totals have a higher degree of accuracy than the "state" entries.

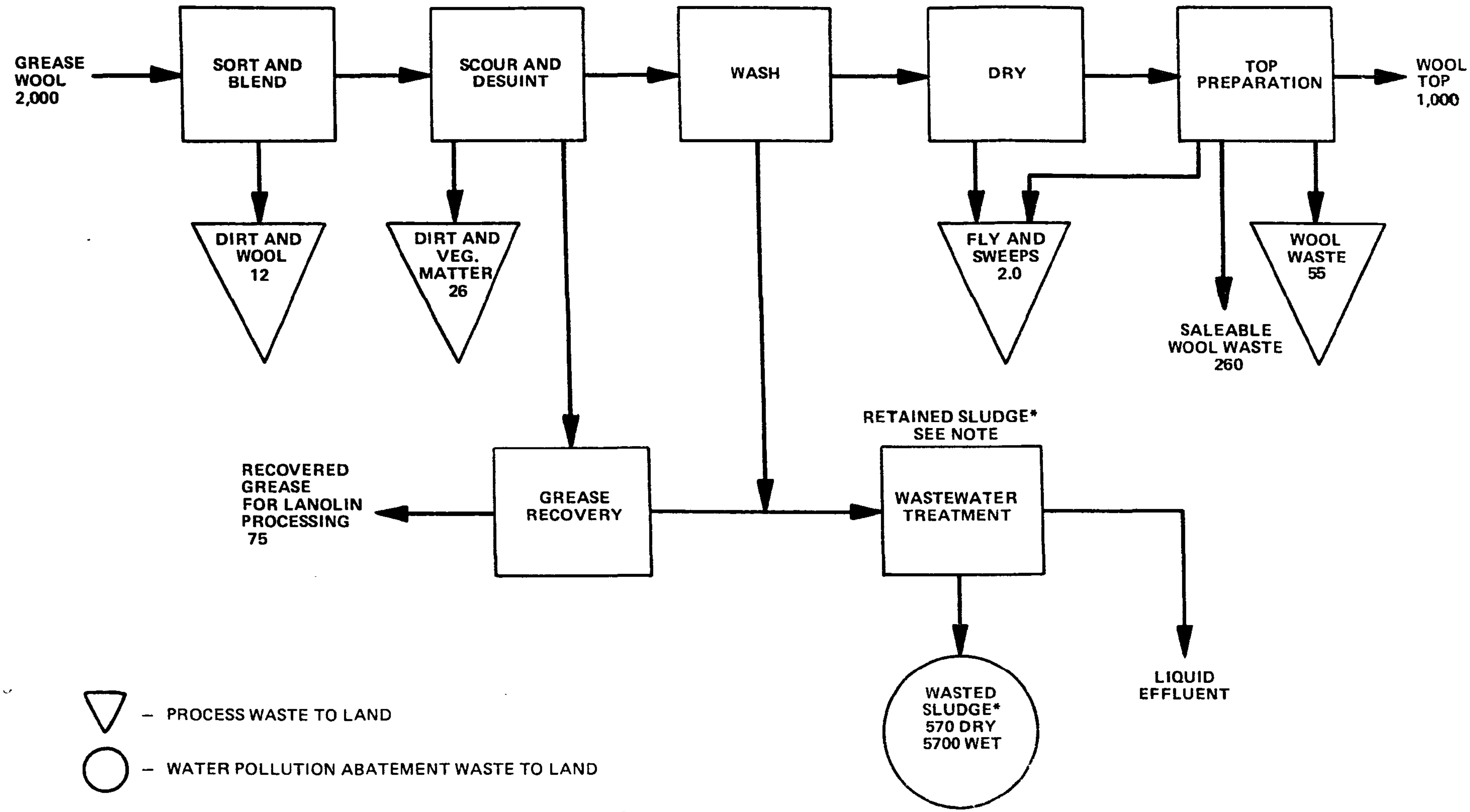
3.4.1 Category A - Wool Scouring

The four plants visited in this category are located in EPA regions I, III and IV. Annual production of the visited plants range from 1,400 metric tons to 5,700 metric tons. A typical plant with wastewater treatment facilities produces 5,600 metric tons/year of product. The number of employees at the four plants range from 85 to 270 and average 180. Plant ages range from 15 to 75 years, and average 33 years. Operations normally run 2 or 3 shifts per day, 5 days per week, 52 weeks per year.

3.4.1.1 Process Description

A mass-balanced flow diagram of the typical wool scouring process is shown in Figure 3-1. Grease wool, received in bales (each bale usually contains the fleece of 2 or 3 sheep) is first sorted and blended with other wool according to the grade of the wool and its ultimate use. The wool is then fed to the scouring train, which consists of several bowls (open tanks) through which the scouring liquor flows countercurrent to the wool flow. Detergent is not added until after the wool passes through the first bowl. Grease-laden water from the first bowl is sent to a grease recovery system. Mechanical separation (heating, settling, centrifuging, recirculating) is the most widely used system in the United States for grease recovery; however, acid cracking is an alternative method of grease recovery. Approximately 3 to 3 1/2 per cent of the

Figure 3-1. CATEGORY A - TYPICAL WOOL SCOURING PROCESS



POTENTIALLY HAZARDOUS CONSTITUENTS:
TOTAL HEAVY METALS** 3.0
TOTAL CHLORINATED ORGANICS 730×10^{-6}

NOTE: AN AVERAGE OF 780 KG (DRY), 7,800 KG (WET) SLUDGE IS RETAINED CONTAINING 4.1 KG TOTAL HEAVY METALS,** AND 1.0×10^{-3} TOTAL CHLORINATED ORGANICS (NOT INCLUDED IN MASS BALANCE).

weight of the grease wool is recoverable and is usually sold to processors who further refine it into lanolin. The scouring operation removes the natural impurities (grease, suint, some vegetable matter, etc.) from the wool. The wool is then washed to remove any traces of the scouring chemicals, and dried. Clean wool may be sold at this point, however, at all the plants visited, it was further processed into top. Top preparation is a series of operations usually consisting of carding, gilling, combing, and final gilling.

3.4.1.2 Waste Stream Descriptions *

Product (wool top) weight is approximately 50 per cent of the raw material (grease wool) weight. This figure may range from about 35 per cent to 55 per cent depending on the grade of wool, its origin, and other variables, but usually averages near 50 per cent for the typical plant and product mix. As a result, this category's total waste (including saleable waste and grease) weighs approximately as much as the product. This category's typical plant land-destined waste streams are summarized as follows:

Waste	Source	Quantity (kg of waste/ kkg of product)
dirt and wool	sorting and blending	12
dirt and vegetable matter	scouring	26
fly and sweeps	drying, top preparation	2
wool waste	top preparation	55
wasted sludge	wastewater treatment	570 (dry) 5,700 (wet)
retained sludge *	wastewater treatment	780 kg (dry) 7,800 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

3.4.1.2.1 Potentially Hazardous or Non-Hazardous Constituents

There are no potentially hazardous constituents in the land-destined wool, dirt, vegetable matter, fly, and sweeps wastes identified in Figure 3-1. Additionally, there are no dye or chemical container wastes (and their potentially hazardous residuals) due to the simplicity of the process, purchase of detergent in bulk, and no dyeing operations. However, potentially hazardous constituents were found in samples of this industry's wastewater treatment sludge. These potentially hazardous constituents are heavy metals and chlorinated organics.

3.4.1.2.2 Sampling Results

Table 3-1 shows the results of analyses performed on composite sludge samples taken weekly over a period of four weeks. In every instance where drinking water limits are established, metals or organics concentrations exceed these limits. Solids content of this sludge was the highest of all categories of the industry. Iron accounted for over 90 per cent by weight of the heavy metals content. Analysis performed for total

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Table 3-1

Category A - Wool Scouring

Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Average(1)
Arsenic	0.05	<0.1(2)
Barium	1.0	59
Cadmium	0.01	1.2
Chromium	0.05	19
Cobalt	**	4.2
Copper	1.0	18
Iron	0.3	4,820
Lead	0.05	28
Manganese	0.05	205
Mercury	0.002	<0.01
Molybdenum	**	<2
Nickel	**	12.5
Zinc	5.0	106
Total Heavy Metals		
Aluminum	**	4,860
Magnesium	60.0	5,560
Potassium	**	9,240
Sodium	**	675
Strontium	**	21.6
Total Chlorinated Organics	0.7	1.28
Suspended Solids (%)	**	9.8
Total Solids (%)	**	10.1

(1) Average of 4 measurements from one plant
(2) Less than values were considered to be at the maximum in computing the totals
* U.S. Public Health Service. Drinking Water Standards. 1962.
** No drinking water standards have been set for these metals.

chlorinated organics showed 99.1 per cent by weight of the total content (1.28 ppm) was in the solid phase of the sludge, with the remainder in the liquid phase. Detailed sampling results may be found in Appendix C of this report.

An average of 780 kg (dry) or 7,800 kg (wet) of sludge is retained in the typical plant's wastewater treatment system, containing 4.1 kg of total heavy metals, and 1.0×10^{-3} kg of chlorinated organics. The typical plant disposes of 570 kg (dry) or 5,700 kg (wet) of sludge for every metric ton of wool top produced. This wasted sludge contains 3 kg of total heavy metals and 7.3×10^{-4} kg of total chlorinated organics.

3.4.1.3 Waste Quantities for 1974, 1977, and 1983

Table 3-2 identifies total wastes for this category in 1974, 1977 and 1983. Waste generation shows no change of status in 1977 and 1983 because production is considered stabilized at the current level for these years.

Sludge quantities and its potentially hazardous constituents amounts appear in Table 3-3 for 1974 and 1977. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered to relate sludge quantities to production for that year. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. Table 3-4 lists the quantities of wastewater treatment sludge expected in 1983. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

Region I is the primary center for this industry, with 40 to 50 per cent of production and wastes. Some state-by-state data has been withheld due to the proprietary nature of production figures, on which waste generation is based.

3.4.2 Category B - Wool Fabric Dyeing and Finishing

The seven facilities visited in this category are located in Massachusetts, Maine, New Hampshire, and Georgia. Annual production of these plants range from 450 metric tons to 9,000 metric tons. The typical plant with wastewater treatment facilities produces 5,200 metric tons annually. None of the seven plants produces 100 per cent wool cloth as a sole product. The following data summarizes various aspects of these plants:

Table 3-2. Category A - Estimated Quantities of Total Wastes from Wool Scouring Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California						
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida						
IV	Georgia						
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	9,300	75,900	9,300	75,900	6,100	18,700
V	Michigan						
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey						
VI	New Mexico						
II	New York						
IV	North Carolina						
VIII	North Dakota						
V	Ohio						
VI	Oklahoma						
X	Oregon	*	*	*	*	*	*
III	Pennsylvania	*	*	*	*	*	*
I	Rhode Island	*	*	*	*	*	*
IV	South Carolina	*	*	*	*	*	*
VIII	South Dakota						
IV	Tennessee						
VI	Texas	7,000	57,400	7,000	57,400	4,500	13,800
VIII	Utah						
I	Vermont						
III	Virginia	*	*	*	*	*	*
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		32,000	261,600	32,000	261,600	20,900	63,800
Region I		13,500	109,800	13,500	109,800	8,800	26,800
II							
III, IV and X		11,600	94,000	11,600	94,000	7,600	23,200
V							
VI		7,000	57,400	7,000	57,400	4,500	13,800
VII							
VIII							
IX							

* Production data was withheld due to its proprietary nature; thus waste quantities are not provided.

Table 3-3. Category A - Quantities of Potentially Hazardous Wastewater Treatment Sludges from Wool Scouring Operations, 1974 and 1977.

	RETAINED SLUDGES[1] (KKG)					WASTED SLUDGES[2]				
	Total Dry	Total Wet	Total Heavy Metals	Total Chlorinated Organics (x 10^{-6})	Total Hazardous Constituents	Total Dry	Total Wet	Total Heavy Metals	Total Chlorinated Organics	Total Hazardous Constituents
IV Alabama										
X Alaska										
IX Arizona										
VI Arkansas										
IX California										
VIII Colorado										
I Connecticut	*	*	*	*	*	*	*	*	*	*
III Delaware										
IV Florida										
IV Georgia										
IX Hawaii										
X Idaho										
V Illinois										
V Indiana										
VII Iowa										
VII Kansas										
IV Kentucky										
VI Louisiana										
I Maine										
III Maryland										
I Massachusetts	2	19	0.01	2.6	0.01	7,400	74,000	39	0.0091	39
V Michigan										
V Minnesota										
IV Mississippi										
VII Missouri										
VIII Montana										
VII Nebraska										
IX Nevada										
I New Hampshire										
II New Jersey										
VI New Mexico										
II New York										
IV North Carolina										
VIII North Dakota										
V Ohio										
VI Oklahoma										
X Oregon	*	*	*	*	*	*	*	*	*	*
III Pennsylvania	*	*	*	*	*	*	*	*	*	*
I Rhode Island	*	*	*	*	*	*	*	*	*	*
IV South Carolina	*	*	*	*	*	*	*	*	*	*
VIII South Dakota										
IV Tennessee										
VI Texas	1	14	0.005	1.3	0.005	5,600	56,000	29	0.0329	29
VIII Utah										
I Vermont										
III Virginia										
X Washington										
III West Virginia										
V Wisconsin										
VIII Wyoming										
TOTAL	6	64	0.03	7.7	0.03	25,000	255,000	134	0.0329	134
Region I	3	27	0.016	3.8	0.016	10,700	107,000	56	0.014	56
II										
III, IV and X	2	23	0.009	2.6	0.009	9,200	82,000	49	0.0117	49
V										
VI	1	14	0.005	1.3	0.005	5,600	56,000	29	0.0072	29
VII										
VIII										
IX										

*Production data withheld because of its proprietary nature; thus waste quantities are not provided.

[1] Retained sludge is so slowly generated by aerated biological treatment of textile wastewaters that, in many cases, there is no need for disposal. Sludge is allowed to accumulate over a period of years and is stored in the treatment pond.

[2] Wasted sludge is excess sludge generated in textile mill wastewater treatment systems which must be removed and disposed of on a regular basis.

Table 3-4. Category A - Quantities of Potentially Hazardous Wastewater Treatment Sludges from Wool Scouring Operations,** 1983 (KKG/YR)

Region	State	Total Potentially Hazardous Waste Dry (x 10^3)	Total Potentially Hazardous Waste Wet (x 10^3)	Total Heavy Metals (x 10^3)	Total Chlorinated Organics (x 10^{-3})	Total Hazardous Constituents (x 10^3)
IV	Alabama					
X	Alaska					
IX	Arizona					
VI	Arkansas					
IX	California					
VIII	Colorado					
I	Connecticut	*	*	*	*	*
III	Delaware					
IV	Florida					
IV	Georgia					
IX	Hawaii					
X	Idaho					
V	Illinois					
V	Indiana					
VII	Iowa					
VII	Kansas					
IV	Kentucky					
VI	Louisiana					
I	Maine					
III	Maryland					
I	Massachusetts	4.2	16.8	0.022	5.3	0.022
V	Michigan					
V	Minnesota					
IV	Mississippi					
VII	Missouri					
VIII	Montana					
VII	Nebraska					
IX	Nevada					
I	New Hampshire					
II	New Jersey					
VI	New Mexico					
II	New York					
IV	North Carolina					
VIII	North Dakota					
V	Ohio					
VI	Oklahoma					
X	Oregon	*	*	*	*	*
III	Pennsylvania	*	*	*	*	*
I	Rhode Island	*	*	*	*	*
IV	South Carolina	*	*	*	*	*
VIII	South Dakota					
IV	Tennessee					
VI	Texas	3.1	12.4	0.017	4.0	0.017
VIII	Utah					
I	Vermont					
III	Virginia	*	*	*	*	*
X	Washington					
III	West Virginia					
V	Wisconsin					
VIII	Wyoming					
TOTAL		14.3	57.2	0.0762	18.3	0.0762
Region I		6	24	0.032	7.7	0.032
II						
III, IV and X		5.2	20.8	0.0272	6.6	0.0272
V						
VI		3.1	12.4	0.017	4.0	0.017
VII						
VIII						
IX						

*Reduction data withheld because of its proprietary nature; thus waste quantities are not provided.

	Range	Average
100% wool cloth output*	0-50%	26%
100% synthetic cloth output*	0-35%	10%
wool blend cloth output*	35-95%	64%
number of employees	160-1700	610
production equipment age	1-40 years	33 years
plant age	20-134 years	64 years

* Figures are percentages of total cloth output

Plants normally operate 2 to 3 shifts per day, 5 to 6 days per week, 50 weeks per year.

3.4.2.1 Process Description

A mass-balanced flow diagram of the typical wool fabric dyeing and finishing process is shown in Figure 3-2. The individual operations are addressed below.

Carbonizing. Not all woolen fabrics are carbonized. Of the seven plants visited, only two carbonized fabric. In this operation, pure wool fabric is usually treated with sulfuric acid and heat to eliminate any vegetable matter and impurities left in the fabric. The char from the impurities can then be dusted from the fabric when it is dry.

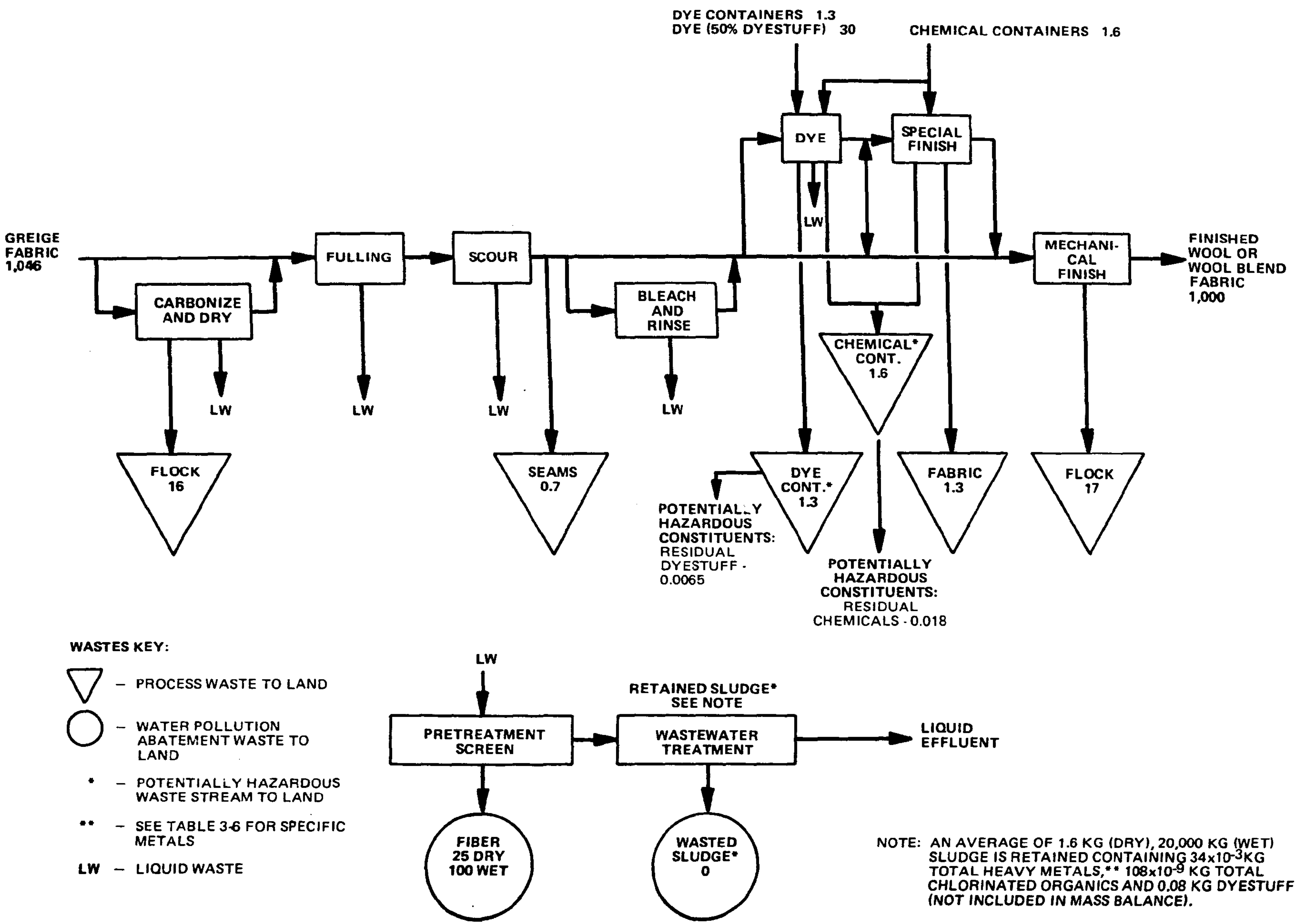
Fulling. Woolen fabrics are subjected to heat, mechanical action, and chemicals which etch the surface of the woolen fibers in an aqueous bath, causing the cloth to mat and shrink and thus become denser. Worsteds usually do not require this process step because they are made of longer fibers which are more tightly woven than the softer, less dimensionally stable woolen fabrics.

Scour. In order to prepare the fabric for dyeing, it is scoured to remove excess chemicals, processing oils, and sizing.

Bleach and rinse. When white cloth is desired or light pastel shades are to be dyed, the cloth may be bleached and then rinsed to remove excess bleaching chemicals.

Dye. Cloth may be beam dyed or piece dyed. Slightly more dye - an estimated 3 per cent of the weight of the cloth as opposed to the usual 2 per cent - may be used in dyeing due to the generally darker shades and deeper dyeing of woolens and worsteds. If the cloth was woven from pre-dyed yarn, or if the cloth was bleached and is to remain white, this operation would be bypassed.

Figure 3-2. CATEGORY B - TYPICAL WOOL OR WOOL BLEND FABRIC DYEING AND FINISHING PROCESS



Special finish. In this operation, chemical finishes such as anti-soils, anti-statics, water-repellents or mothproofs may be applied. Currently, very little mothproofing is done. (Some government contracts require mothproofing, but mothproofing in this industry is an uncommon occurrence).

Mechanical finish. Decatizing (treating with hot water or steam), napping or brushing, shearing and pressing are common mechanical finishing operations performed on the fabric to remove wrinkles, improve the hand of the cloth, or alter its surface characteristics. The cloth may pass through any one or usually several of these operations.

3.4.2.2 Waste Stream Description *

This category's typical plant land-destined waste streams are:

Waste	Source	Quantity (kg of waste/ kkg of product)
flock	carbonizing and drying	16
seams	scouring	0.7
dye containers	dyeing	1.3
chemical containers	dyeing, special finishing	1.6
fabric	special finishing	1.3
flock	mechanical finishing	17
fiber	wastewater pretreatment screening	25 (dry) 100 (wet)
wasted sludge	wastewater treatment	none
retained sludge*	wastewater treatment	1.6 kg (dry) 20,000 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

3.4.2.2.1 Potentially Hazardous or Non-Hazardous Constituents

The flock, seams, fabric, and fiber wastes identified in Figure 3-2 are considered non-hazardous. The dye and chemical container waste streams are considered potentially hazardous because they contain hazardous residuals such as dyestuff and zinc compounds. The potentially hazardous portions of the dye container and chemical container waste streams are 0.0065 kg/kkg of product and 0.018 kg/kkg of product, respectively. Sludges retained in the wastewater treatment system (typically, no sludges are disposed of by this industry category) contain potentially hazardous heavy metals and dyestuff.

3.4.2.2.2 Sampling Results

Table 3-5 lists the results of analyses performed on composite sludge samples taken weekly over a period of four weeks at one plant. In

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

every instance where drinking water limits have been set, metals concentrations exceed these limits. Solids content of this sludge was the lowest of all categories of the industry. Total heavy metals concentration (20,900 mg/kg of dry sludge) in this category's sludge was the highest of all categories, with iron and manganese together accounting for just slightly more than 90 per cent by weight of the total heavy metals content, while chromium accounted for less than 2 per cent of the total heavy metals content. This is due, in part, to this category's continuing effort to reduce usage of chrome dyes, (and hence chromium in plant effluent) which were once important in wool fabric dyeing. Total chlorinated organics analysis was not performed on the solid phase of the sludge in this category. There was not enough solids content in the samples to analyze. Detailed sampling results appear in Appendix C.

An average of 1.6 kg (dry) or 20,000 kg (wet) of sludge is retained in the typical direct discharge plant's wastewater treatment system, containing 34×10^{-3} kg of total heavy metals, 1.8×10^{-7} kg of total chlorinated organics, and 0.08 kg of dyestuff. The amounts of chlorinated organics found in the liquid phase of the sludge is below the drinking water standard of 0.7 ppm.

3.4.2.3 Waste Quantities for 1974, 1977 and 1983

Table 3-6 identifies total wastes for this category in 1974, 1977 and 1983. Total waste generation shows no change of status in 1977 and 1983 because production is considered stabilized at the current level for these years.

Table 3-7 lists dye and chemical container and potentially hazardous container residuals wastes for 1974, 1977 and 1983. These wastes also show no change because of stabilized future production.

Sludge quantities and its potentially hazardous constituents amounts appear in Tables 3-8, 3-9 and 3-10 for 1974, 1977 and 1983, respectively. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered valid to relate sludge quantities to production for that year. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

3.4.3 Category C - Greige Goods

The estimate has been reported (8) that 80 per cent of the 600 to 700 greige woven goods mills are located in Alabama, Georgia, North Carolina, South Carolina, and Virginia. The five greige mills visited were located in Alabama, Georgia, North Carolina, and South Carolina.

Table 3-5

Category B - Wool Fabric
Dyeing & Finishing
Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Average (1)
Arsenic	0.05	<17 (2)
Barium	1.0	<170
Cadmium	0.01	<17
Chromium	0.05	267
Cobalt	**	<67
Copper	1.0	117
Iron	0.3	1100
Lead	0.05	<170
Manganese	0.05	8,000
Mercury	0.002	<1.7
Molybdenum	**	<333
Nickel	**	<33
Zinc	5.0	1,130
Total Heavy Metals		11,423
Aluminum	**	11,500
Magnesium	60.0	12,000
Potassium	**	14,000
Sodium	**	137,000
Strontium	**	170
Total Chlorinated Organics	0.7	0.11
Suspended Solids (%)	**	0.008
Total Solids (%)	**	0.06

(1) Average of 4 measurements from one plant
(2) Less than values were considered to be at the maximum in computing the totals
* U.S. Public Health Service. Drinking Water Standards. 1962
** No drinking water standards have been set for these metals

Table 3-6. Category B - Estimated Quantities of Total Wastes from Wool Fabric Dyeing and Finishing Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	189	416	189	417	459	1,489
VIII	Colorado						
I	Connecticut	692	1,560	692	1,512	1,672	5,452
III	Delaware						
IV	Florida						
IV	Georgia	880	1,975	880	1,977	2,080	6,740
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa	189	416	189	417	459	1,489
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine	1,572	3,535	1,572	3,539	3,872	12,672
III	Maryland						
I	Massachusetts	2,727	6,137	2,727	6,147	6,727	22,027
V	Michigan	315	708	315	709	775	2,535
V	Minnesota	189	416	189	417	459	1,489
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	1,007	2,287	1,007	2,289	2,407	7,847
II	New Jersey	7,887	4,163	7,887	4,168	4,587	14,887
VI	New Mexico						
II	New York	1,781	3,952	1,781	3,956	4,281	13,881
IV	North Carolina	1,572	3,535	1,572	3,539	3,872	12,672
VIII	North Dakota						
V	Ohio	189	416	189	417	459	1,489
VI	Oklahoma						
X	Oregon	692	1,560	692	1,562	1,672	5,452
III	Pennsylvania	1,781	3,952	1,781	3,956	4,281	13,881
I	Rhode Island	1,607	2,287	1,607	2,289	2,407	7,847
IV	South Carolina	692	1,560	692	1,562	962	2,612
VIII	South Dakota						
IV	Tennessee	189	416	189	417	459	1,489
VI	Texas	503	1,143	503	1,144	1,223	4,003
VIII	Utah	189	416	189	417	459	1,489
I	Vermont	315	708	315	709	775	2,535
III	Virginia	503	1,143	503	1,144	1,223	4,003
X	Washington	189	416	189	417	459	1,489
III	West Virginia						
V	Wisconsin	189	416	189	417	459	1,489
VIII	Wyoming						
TOTAL		19,438	43,533	19,438	43,588	46,488	150,958
Region	I	7,320	16,514	7,320	16,535	17,860	58,380
	II	3,668	8,115	3,668	8,124	8,868	28,768
	III	2,284	5,095	2,284	5,100	5,504	17,884
	IV	3,333	7,486	3,333	7,495	7,373	23,513
	V	882	1,956	882	1,960	2,152	7,002
	VI	503	1,143	503	1,144	1,223	4,003
	VII	189	416	189	417	459	1,489
	VIII	189	416	189	417	459	1,489
	IX	189	416	189	417	459	1,489
	X	881	1,976	881	1,979	2,131	6,941

Table 3-7. Category B - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Wool Fabric Dyeing and Finishing Operations, 1974, 1977, and 1983 (KKG/YR.) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals*	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	3.9	0.020	4.8	0.054	8.774	0.074
VIII	Colorado						
I	Connecticut	14	0.072	18	0.020	32.092	0.092
III	Delaware						
IV	Florida						
IV	Georgia	18	0.091	22	0.25	40.341	0.341
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa	3.9	0.020	4.8	0.054	8.774	0.074
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine	32	0.16	40	0.45	72.61	0.61
III	Maryland						
I	Massachusetts	57	0.29	70	0.79	128.08	1.08
V	Michigan	6.5	0.032	8	0.090	14.622	0.122
V	Minnesota	3.9	0.020	4.8	0.054	8.774	0.074
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	21	0.10	26	0.29	47.39	0.39
II	New Jersey	39	0.20	48	0.54	87.74	0.74
VI	New Mexico						
II	New York	36	0.18	45	0.50	81.68	0.68
IV	North Carolina	32	0.16	40	0.45	72.61	0.61
VIII	North Dakota						
V	Ohio	3.9	0.020	4.8	0.054	8.774	0.074
VI	Oklahoma						
X	Oregon	14	0.072	18	0.20	32.272	0.272
III	Pennsylvania	36	0.18	45	0.50	81.68	0.68
I	Rhode Island	21	0.10	26	0.29	47.39	0.39
IV	South Carolina	14	0.072	18	0.20	32.272	0.272
VIII	South Dakota						
IV	Tennessee	3.9	0.020	4.8	0.054	8.774	0.074
VI	Texas	10	0.052	13	0.14	23.192	0.192
VIII	Utah	3.9	0.020	4.8	0.054	8.774	0.074
I	Vermont	6.5	0.032	8	0.090	14.622	0.122
III	Virginia	10	0.052	13	0.14	23.192	0.192
X	Washington	3.9	0.020	4.8	0.054	8.774	0.074
III	West Virginia						
V	Wisconsin	3.9	0.020	4.8	0.054	8.774	0.074
VIII	Wyoming						
TOTAL		398.2	2.005	496.4	5.372	901.977	7.377
Region	I	151.5	0.754	188	1.93	342.184	2.684
	II	75	0.38	93	1.04	169.42	1.42
	III	46	0.232	58	0.64	104.872	0.872
	IV	67.9	0.343	84.8	0.954	153.997	1.297
	V	18.2	0.092	22.4	0.252	40.944	0.344
	VI	10	0.052	13	0.14	23.192	0.192
	VII	3.9	0.020	4.8	0.054	8.774	0.074
	VIII	3.9	0.020	4.8	0.054	8.774	0.074
	IX	3.9	0.020	4.8	0.054	8.774	0.074
	X	17.9	0.092	22.8	0.254	41.046	0.346

* Dry Weight = Wet Weight

Table 3-8. Category B – Quantities of Potentially Hazardous Wastewater Treatment Sludges from Wool Fabric Dyeing and Finishing Operations, 1974 (KKG)

Region	State	RETAINED SLUDGES* (NO WASTED SLUDGES) Total Pot. Haz. Waste: Total Dry (x 10^{-3})	Total Pot. Haz. Waste: Total Wet	Total Heavy Metals (x 10^{-6})	Total Chlorinated Organics (x 10^{-11})	Dyestuff (x 10^{-3})	Total Hazardous Constituents (x 10^{-6})
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	0.60	7.6	12	6.6	0.03	42
VIII	Colorado						
I	Connecticut	2.2	28	46	24	0.11	156
III	Delaware						
IV	Florida						
IV	Georgia	2.8	35	59	31	0.14	199
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa	0.60	7.6	12	6.6	0.03	42
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine	5.0	63	100	55	0.25	350
III	Maryland						
I	Massachusetts	8.8	110	180	97	0.44	620
V	Michigan	1.0	13	21	11	0.05	71
V	Minnesota	0.60	7.6	12	6.6	0.03	42
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	3.2	40	67	35	0.16	227
II	New Jersey	6.0	76	120	66	0.30	420
VI	New Mexico						
II	New York	5.6	71	110	62	0.28	390
IV	North Carolina	5.0	63	100	55	0.25	350
VIII	North Dakota						
V	Ohio	0.60	7.6	12	6.6	0.03	42
VI	Oklahoma						
X	Oregon	2.2	28	46	24	0.11	156
III	Pennsylvania	5.6	71	110	62	0.28	390
I	Rhode Island	3.2	40	67	35	0.16	227
IV	South Carolina	2.2	28	46	24	0.11	156
VIII	South Dakota						
IV	Tennessee	0.60	7.6	12	6.6	0.03	42
VI	Texas	1.6	20	34	18	0.08	114
VIII	Utah	0.60	7.6	12	6.6	0.03	42
I	Vermont	1.0	13	21	11	0.05	71
III	Virginia	1.6	20	34	18	0.08	114
X	Washington	0.60	7.6	12	6.6	0.03	42
III	West Virginia						
V	Wisconsin	0.60	7.6	12	6.6	0.03	42
VIII	Wyoming						
TOTAL		61.8	779.8	1257	680.8	3.09	4,347
Region I		23.4	294	481	257	1.17	1,651
II		11.6	147	230	128	0.58	810
III		7.2	91	144	80	0.36	504
IV		10.6	133.6	217	116.6	0.53	747
V		2.8	35.8	57	30.8	0.14	197
VI		1.6	20	34	18	0.08	114
VII		0.60	7.6	12	6.6	0.03	42
VIII		0.60	7.6	12	6.6	0.03	42
IX		0.60	7.6	12	6.6	0.03	42
X		2.8	35.6	58	30.6	0.14	198

*Retained sludge is so slowly generated by aerated biological treatment of textile wastewaters that, in many cases, there is no need for disposal. Sludge is allowed to accumulate over a period of years and is stored in the treatment pond. Wasted sludge is excess sludge generated in textile mill wastewater treatment systems which must be removed and disposed of on a regular basis.

Table 3-9. Category B - Quantities of Potentially Hazardous Wastewater Treatment Sludges from Wool Fabric Dyeing and Finishing Operations, 1977 (KKG)

		RETAINED SLUDGES* (NO WASTED SLUDGES)					
		Total Pot. Haz. Waste					
		Total Dry (x 10^-3)*	Total Wet	Total Heavy Metals (x 10^-6)	Total Chlorinated Organics (x 10^-11)	Dyestuff (x 10^-3)	Total Hazardous Constituents (x 10^-6)
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	0.64	8.1	13	7.0	0.03	43
VIII	Colorado						
I	Connecticut	2.3	30	49	25	0.12	169
III	Delaware						
IV	Florida						
IV	Georgia	3.0	37	62	33	0.15	212
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa	0.64	8.1	13	7.0	0.03	43
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine	5.3	67	110	58	0.26	370
III	Maryland						
I	Massachusetts	9.3	120	190	100	0.47	660
V	Michigan	1.1	14	22	12	0.05	72
V	Minnesota	0.64	8.1	13	7.0	0.03	43
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	3.4	42	71	37	0.17	241
II	New Jersey	6.4	81	130	70	0.32	450
VI	New Mexico						
II	New York	5.9	75	120	66	0.30	420
IV	North Carolina	5.3	67	110	58	0.26	370
VIII	North Dakota						
V	Ohio	0.64	8.1	13	7.0	0.03	43
VI	Oklahoma						
X	Oregon	2.3	30	49	25	0.12	169
III	Pennsylvania	5.9	75	120	66	0.30	420
I	Rhode Island	3.4	42	71	37	0.17	241
IV	South Carolina	2.3	30	49	25	0.12	169
VIII	South Dakota						
IV	Tennessee	0.64	8.1	13	7.0	0.03	43
VI	Texas	1.7	21	36	19	0.08	116
VIII	Utah	0.64	8.1	13	7.0	0.03	43
I	Vermont	1.1	14	22	12	0.05	72
III	Virginia	1.7	21	36	19	0.08	116
X	Washington	0.64	8.1	13	7.0	0.03	43
III	West Virginia						
V	Wisconsin	0.64	8.1	13	7.0	0.03	43
VIII	Wyoming						
TOTAL		65.52	830.8	1351	718	3.26	4,611
Region I		24.8	315	513	269	1.24	1,753
II		12.3	156	250	136	0.62	870
III		7.6	96	156	85	0.38	536
IV		11.24	142.1	234	123	0.56	794
V		3.02	38.3	61	33	0.14	201
VI		1.7	21	36	19	0.08	116
VII		0.64	8.1	13	7	0.03	43
VIII		0.64	8.1	13	7	0.03	43
IX		0.64	8.1	13	7	0.03	43
X		2.94	38.1	62	32	0.15	212

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-10. Category B - Quantities of Potentially Hazardous Wastewater Treatment Sludges From Wool Fabric Dyeing and Finishing Operations, 1983 (KKG)

Region	State	Total Potentially Hazardous Waste		Total Heavy Metals	Total Chlorinated Organics ($\times 10^{-6}$)	Dyestuff	Total Hazardous Constituents
		Dry	Wet				
IV	Alabama						
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	270	1,080	5.7	30	14	19.7
VIII	Colorado						
I	Connecticut	980	3,420	20	100	49	69
III	Delaware						
IV	Florida						
IV	Georgia	1,200	4,800	26	140	60	86
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana						
VII	Iowa	270	1,080	5.7	30	14	19.7
VII	Kansas						
IV	Kentucky						
VI	Louisiana						
I	Maine	2,300	9,200	47	250	120	167
III	Maryland						
I	Massachusetts	4,000	16,000	83	440	200	283
V	Michigan	460	1,840	9.8	50	23	32.8
V	Minnesota	270	1,080	5.7	30	14	19.7
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	1,400	5,600	30	160	70	100
II	New Jersey	2,700	10,800	57	300	140	197
VI	New Mexico						
II	New York	2,500	10,000	53	280	120	173
IV	North Carolina	2,300	9,200	47	250	120	167
VIII	North Dakota						
V	Ohio	270	1,080	5.7	30	14	19.7
VI	Oklahoma						
X	Oregon	980	3,920	20	100	49	69
III	Pennsylvania	2,500	10,000	53	280	120	173
I	Rhode Island	1,400	5,600	30	160	70	100
IV	South Carolina	270	1,080	5.7	30	14	19.7
VIII	South Dakota						
IV	Tennessee	270	1,080	5.7	30	14	19.7
VI	Texas	720	2,880	15	78	36	51
VIII	Utah	270	1,080	5.7	30	14	19.7
I	Vermont	460	1,840	9.8	50	23	32.8
III	Virginia	720	2,880	15	78	36	51
X	Washington	270	1,080	5.7	30	14	19.7
III	West Virginia						
V	Wisconsin	270	1,080	5.7	30	14	19.7
VIII	Wyoming						
TOTAL		27,050	108,200	566.9	2986	1362	1928.9
Region I		10,540	42,160	219.8	1160	532	751.8
II		5,200	20,800	110	580	260	370
III		3,220	12,880	68	358	156	224
IV		4,040	16,160	84.4	450	208	292.4
V		1,270	5,080	26.9	140	65	91.9
VI		720	2,880	15	78	36	51
VII		270	1,080	5.7	30	14	19.7
VIII		270	1,080	5.7	30	14	19.7
IX		270	1,080	5.7	30	14	19.7
X		1,250	5,000	25.7	130	63	88.7

*It was not possible to differentiate between the retained and wasted sludge for 1983, so the estimated values for this year reflect the total quantity.

Three of the plants' production equipment range are in the age range of 5 to 20 years. One of the remaining two plants' equipment is older than 20 years, the other's is newer than 5 years. Operations at these plants normally run 3 shifts per day, 6 to 7 days per week, 50 to 52 weeks per year. Two of the plants are older than 65 years, while the remaining three are six years old. The number of employees range from 130 to 520, and average 300. Annual production ranges from 2,700 to 49,000 metric tons and excluding the largest plant, averages 4,400 metric tons. The plants either produce knitted greige goods (three plants) or woven greige goods (2 plants).

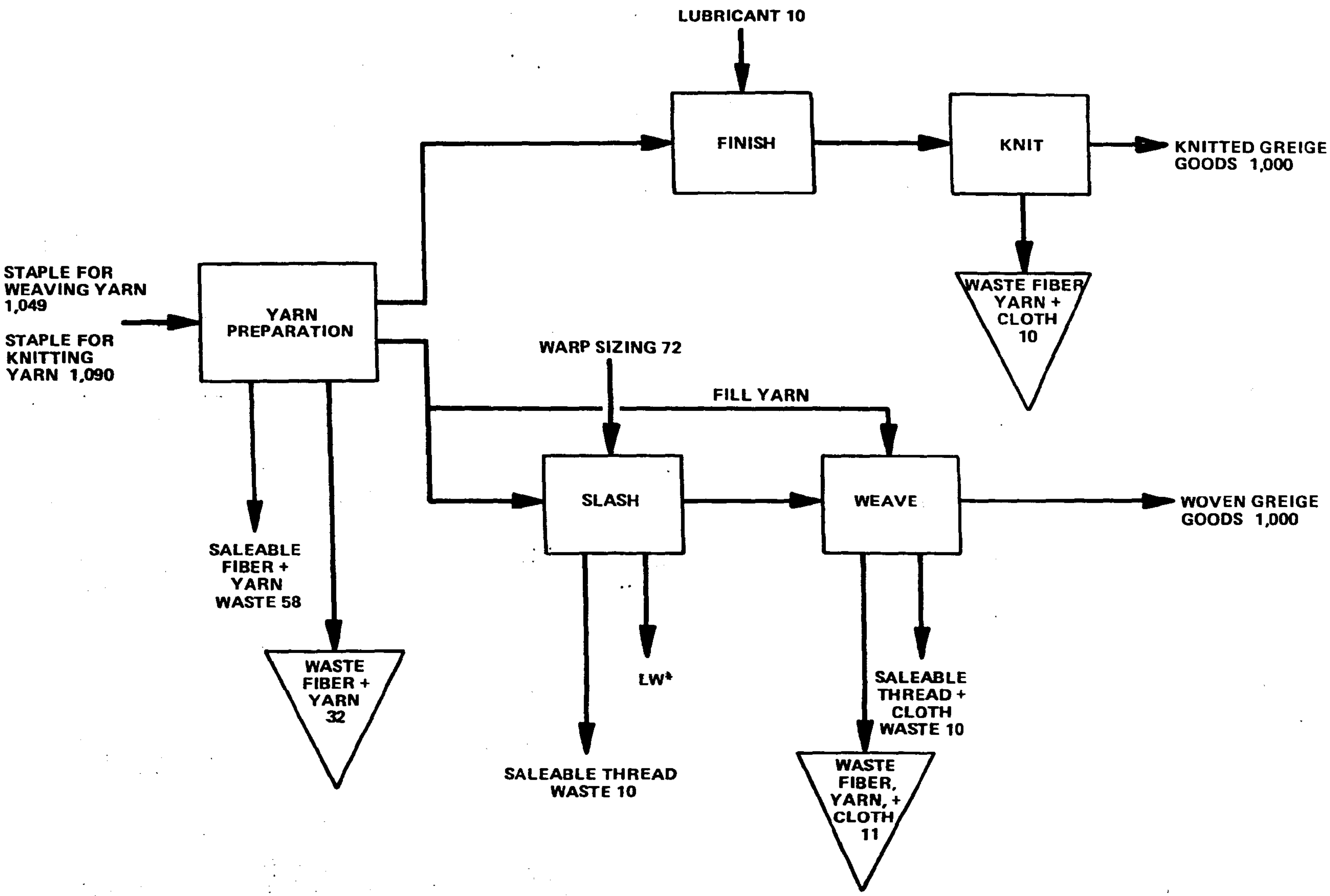
3.4.3.1 Process Description

A mass balanced flow diagram of the typical greige goods process is shown in Figure 3-3.

Yarn preparation consists of several operations. The operations performed are dependent on the type of fiber being processed. The following generally sequential listing serves only to identify those operations commonly in use in yarn preparation, beginning with staple and ending with yarn ready for slashing or finishing prior to weaving or knitting: opening, picking, blending, carding, drawing, roving, spinning, quilling, beaming (warping) or winding. The reader should refer to the glossary for an explanation of these processes involved in yarn preparation if more information is desired. For the purposes of this report, it is sufficient to list these operations here as part of yarn preparation without detailed discussion. Yarn destined for knitting operations is usually finished with a lubricant, commonly an oil or a wax emulsion. Thread destined for sewing leaves the process after finishing. Warp yarns, destined for weaving, are slashed with compounds such as carboxymethyl cellulose (CMC), polyvinyl alcohol (PVA), or starch, among others, in order to withstand the abrasion of the shuttle as it passes over the warp yarns. (It is unnecessary to slash the filling yarn which is carried by the shuttle.)

The slashed or finished yarns are either woven or knitted into greige goods, the input for Categories D and E - Woven Fabric and Knit Fabric Dyeing and Finishing, respectively. It should be noted that there are basically five different types of plants in which greige goods operations may occur, identifiable depending on where the operations stop. Plants may end processing after: (1) yarn preparation, (2) knitting, or (3) weaving. However, in larger "integrated" plants, greige goods production may occur in a sequence of operations beginning with yarn preparation and usually ending with either (4) dyeing and/or finishing the woven goods (Category D) or (5) dyeing and/or finishing the knit goods (Category E). Few integrated plants dye and finish equal amounts of knit and woven greige goods.

Figure 3-3. CATEGORY C - TYPICAL GREIGE GOODS PROCESS



** LIQUID WASTE CONTAINS MOSTLY BOD. THERE ARE NO POTENTIALLY HAZARDOUS WASTES DESTINED FOR LAND DISPOSAL IN THIS CATEGORY.*

3.4.3.2 Waste Stream Descriptions

This category's land-destined waste streams are:

Waste	Source	Quantity (kg of waste/ kkg of product)
Fiber and yarn	yarn preparation	32
Fiber, yarn and cloth	knitting	10
Fiber, yarn and cloth	weaving	11

Much of the waste fibers and yarns in this category can be sold (for garnetting) or reprocessed within the yarn preparation operation (especially in wool yarn manufacture).

3.4.3.2.1 Potentially Hazardous or Non-Hazardous Constituents

No potentially hazardous wastes are destined for land disposal from this category. All land-destined wastes are non-hazardous.

3.4.3.2.2 Sampling Results

Because there are no potentially hazardous wastes generated by this category, no sampling was performed.

3.4.3.3 Rationale for Extrapolation of Waste Quantities to Entire Industry Category

Waste quantities were keyed to production rates. Waste generation rates (53 kg of waste/metric ton of product) identified in Figure 3-3, were applied to estimated production figures to yield total waste amounts.

3.4.3.4 Waste Quantities for 1974, 1977 and 1983

Because products in this category are ultimately used for apparel, furnishings, and other consumer products, waste projections are closely related to population growth. (A standard Census Department growth factor of 3 per cent per annum was applied.) Estimated total waste quantities for 1974, 1977 and 1983 are shown in Table 3-11. Eighty-three per cent of the total waste is generated in EPA Regions II, III and IV. Region IV alone generates 47 per cent of the total.

3.4.4 Category D - Woven Fabric Dyeing and Finishing

The 22 plants visited in this category are located in Alabama, Georgia, Massachusetts, North Carolina, South Carolina, Rhode Island and Virginia. Their annual productions range from 2,700 to 82,000 metric tons. The typical plant with wastewater treatment facilities produces 5,600 metric tons annually. The number of employees at the 22 plants ranges from 75 to 2,000 and averages 650. Plant ages range from 11 to 75 years, averaging 39 years. Operations normally run 3 shifts per day, 5 days per week, 50 weeks per year. The typical product is a polyester-cotton blend fabric,

Table 3-11. Category C. - Estimated Quantities of Total Wastes from Greige Goods Operations, Dry Basis* (KKG/YR)

		1974	1977	1983
IV	Alabama	2,400	2,626	3,125
X	Alaska			
IX	Arizona			
VI	Arkansas	600	657	781
IX	California	6,700	7,332	8,723
VIII	Colorado	200	219	260
I	Connecticut	1,200	1,313	1,562
III	Delaware	100	109	130
IV	Florida	4,800	5,253	6,249
IV	Georgia	14,000	15,321	18,226
IX	Hawaii			
X	Idaho	50	55	65
V	Illinois	2,400	2,626	3,125
V	Indiana	600	657	781
VII	Iowa	200	219	260
VII	Kansas	200	219	260
IV	Kentucky	400	438	521
VI	Louisiana	400	438	521
I	Maine	300	328	391
III	Maryland	400	438	521
I	Massachusetts	3,000	3,283	3,906
V	Michigan	1,000	1,094	1,302
V	Minnesota	900	985	1,172
IV	Mississippi	1,000	1,094	1,302
VII	Missouri	300	328	391
VIII	Montana	50	55	65
VII	Nebraska	400	438	521
IX	Nevada			
I	New Hampshire	400	438	521
II	New Jersey	11,000	12,038	14,321
VI	New Mexico	100	109	130
II	New York	26,000	28,453	33,849
IV	North Carolina	38,000	41,585	49,472
VIII	North Dakota			
V	Ohio	2,000	2,189	2,604
VI	Oklahoma	700	766	911
X	Oregon	700	766	911
III	Pennsylvania	17,000	18,604	22,132
I	Rhode Island	1,700	1,860	2,213
IV	South Carolina	9,400	10,286	12,238
VIII	South Dakota			
IV	Tennessee	4,900	5,362	6,379
VI	Texas	1,200	1,313	1,562
VIII	Utah	200	219	260
I	Vermont	300	328	391
III	Virginia	2,300	2,517	2,994
X	Washington	700	766	911
III	West Virginia	200	219	260
V	Wisconsin	600	657	781
VIII	Wyoming			
TOTAL		159,000	174,000	207,000
Region	I	6,900	7,551	8,983
	II	37,000	40,490	48,170
	III	20,000	21,887	26,038
	IV	74,900	81,966	97,510
	V	7,500	8,208	9,764
	VI	3,000	3,283	3,906
	VII	1,100	1,204	1,432
	VIII	450	492	586
	IX	6,700	7,332	8,723
	X	1,450	1,587	1,888

* Dry basis equals wet basis

although some plants were visited that process solely 100 per cent cotton fabric or solely 100 per cent synthetic fabric. A wide variety of operations were viewed, including printworks, fabric bonders, and commission finishers or converters.

3.4.4.1 Process Description

A mass balanced flow diagram of the typical woven fabric dyeing and finishing process is shown in Figure 3-4. The individual operations are addressed below.

Singe. Normally the first operation in the series of finishing steps, the fabric usually passes rapidly over an open flame, thus burning off any surface hairiness and giving a smoother surface to the fabric. Singeing may be bypassed completely.

Desize. This step may also be bypassed. Some fabrics, such as denim and drapery goods, are "loom finished" and the size remains on the cloth permanently. Other fabrics, made of stronger warp yarns may not require slashing and hence would not require desizing. In this step, the cloth runs through a bath containing the desizing agent, such as an enzyme for starch size or detergents or acid in other cases, which assists in removing the size without damaging the cloth.

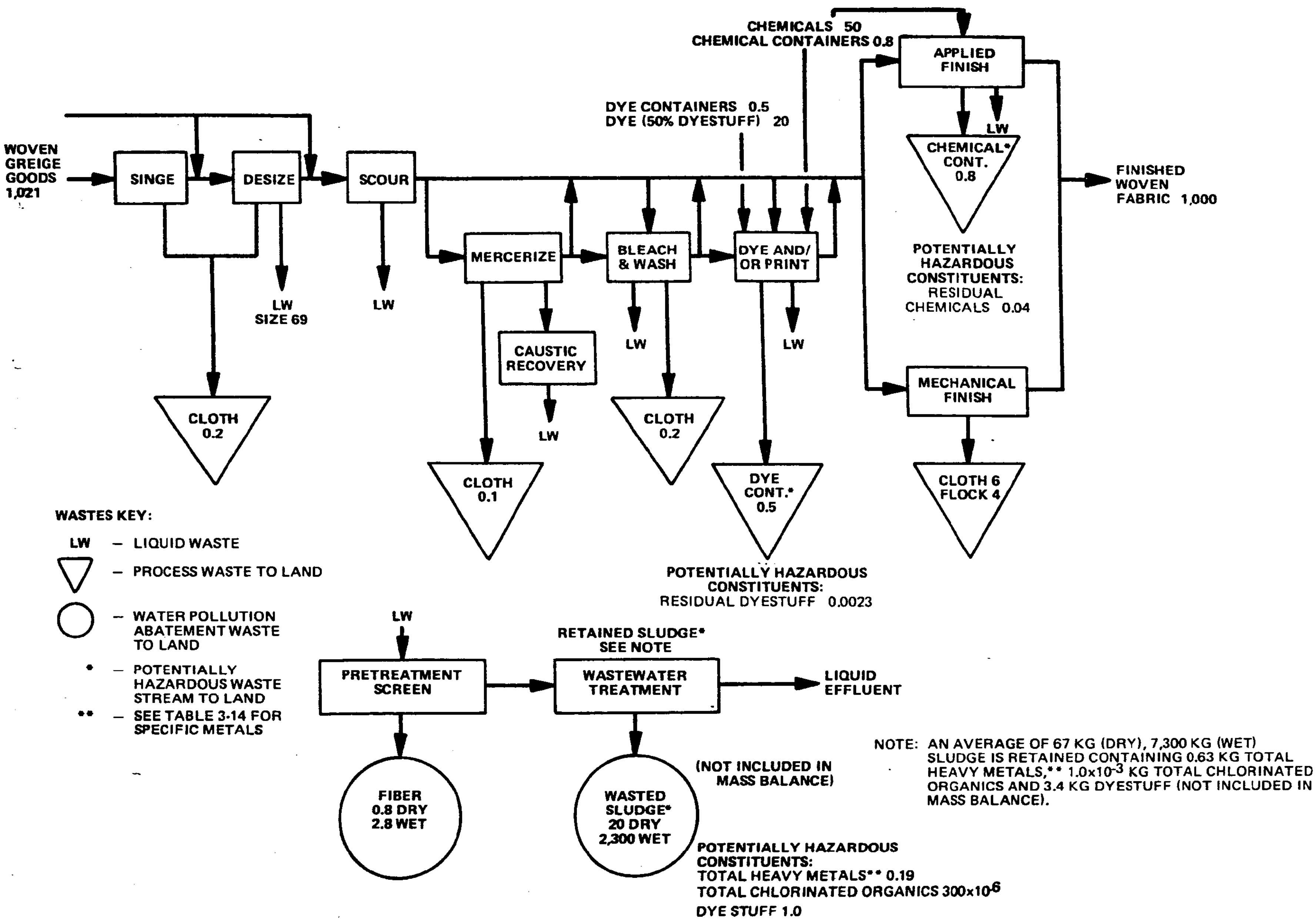
Scour. In processing cotton fabrics, the cloth may be kier scoured (boiled) in a caustic bath to remove any unwanted impurities. If polyester-cotton blends are involved, a separate type of scouring is done. This process removes wax and non-cellulosic components and prepares the cloth for dyeing.

Mercerize. This operation is performed on some pure cotton fabrics. The fabric is treated by a concentrated caustic bath and a final acid (neutralizing) wash. Mercerization swells the cotton fiber, imparting increased dye affinity, tensile strength, and luster to the fabric.

Bleach and Wash. Fabric which is to remain white or to be dyed very light shades is bleached and then washed to remove excess bleaching chemicals.

Dye and/or Print. Fabrics which are to be dyed go to a dye beck, jig, or continuous dye range, where an average amount of dye equivalent to 2 per cent of the weight of the fabric is used in the bath. If the cloth was woven from pre-dyed yarn, or if the cloth was bleached and is to remain white, this operation would be bypassed. White or dyed fabrics which are to be printed may be flat-bed printed, roller printed, or rotary screen printed. For

Figure 3-4. CATEGORY D - TYPICAL WOVEN FABRIC DYEING AND FINISHING PROCESS



detailed information on dyeing and printing techniques and equipment, the reader is referred to the two sections of the glossary (Appendix A) entitled "dyeing" and "printing".

Applied Finish. Chemical finishes such as anti-statics, anti-soils, fire retardants, softeners, water repellents and permanent press resins may be applied. Additionally, fabrics may be bonded together in this step. This process may be bypasssd altogether, or be either preceded or followed by mechanical finishing.

Mechanical Finish. Brushing, napping, shearing, pressing, sanforizing, tenterizing, heat setting, calendering, and sanding are common mechanical finishing operations which remove wrinkles, improve the hand of the cloth, its dimensional stability or shrinkage characteristics, or alter its surface characteristics. The cloth may pass through any one or usually several of these operations. Mechanical finishing may be bypassed altogether or either preceded or followed by chemical finishing.

3.4.4.2 Waste Stream Descriptions *

This category's typical plant land-destined waste streams are:

Waste	Source	Quantity (kg of waste/ kkg of product)
cloth	singe and desize	0.2
cloth	mercerize	0.1
cloth	bleach and wash	0.2
cloth	mechanical finish	6
flock	mechanical finish	4
dye containers	dye and/or print	0.5
chemical containers	dye and/or print, applied finish	0.8
fiber	wastewater pretreatment screening	0.8 (dry) 2.8 (wet)
wasted sludge	wastewater treatment	20 (dry) 2,300 (wet)
retained sludge*	wastewater treatment	67 kg (dry) 7,300 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

3.4.4.2.1 Potentially Hazardous or Non-Hazardous Constituents

The flock, fiber and cloth wastes identified in Figure 3-4 are considered non-hazardous. The dye and chemical container waste streams are considered potentially hazardous because they contain potentially hazardous residual dyestuff and chemicals. The potentially hazardous portions of the dye container and chemical container waste streams were determined to be 0.0023 kg/kkg of product and 0.04 kg/kkg of product, respectively.

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Sludges in the wastewater treatment system also contain hazardous constituents such as heavy metals (chromium, copper, zinc), chlorinated organics and dyestuff and therefore, are also considered potentially hazardous.

3.4.4.2.2 Sampling Results

Table 3-12 lists the results of the analyses performed on the composite sludge samples taken weekly over a period of four weeks from five plants. In every instance metals or organics concentrations in the solid phase of the sludge exceeded the drinking water limits. However, the chlorinated organics concentration in the liquid phase of sludge was less than the drinking water standard for total organics of 0.7 ppm in all cases. The total heavy metals content (9,395 mg/kg of dry sludge) was the second highest, exceeded only by Category B - Wool Fabric Dyeing and Finishing (20,900 mg/kg of dry sludge). Iron accounted for 52 per cent by weight of the total heavy metal content. Zinc accounted for 25 per cent of the total heavy metal content. This may be due in part to the use of zinc nitrate as a catalyst in the application of permanent press resins. Analysis performed for total chlorinated organics showed 98.8 per cent by weight of the total content (15.2 ppm) was found in the solid phase of the sludge, with the remainder in the liquid phase. Detailed sampling results may be found in Appendix C of this report.

An average of 67 kg (dry) or 7,300 kg (wet) of sludge is retained in the typical plant's wastewater treatment system, containing 0.63 kg of total heavy metals, 1.3×10^{-3} kg of total chlorinated organics, and 3.4 kg of dyestuff.

3.4.4.3 Waste Quantities for 1974, 1977 and 1983

Because products in this category are ultimately used for apparel, furnishings, and other consumer products, waste projections are closely related to population growth. (A growth factor of 3 per cent per annum was applied.) Table 3-13 quantifies the total wastes for this category for 1974, 1977 and 1983.

Tables 3-14, 3-15 and 3-16 list dye and chemical container and potentially hazardous container residuals wastes for 1974, 1977 and 1983, respectively.

Sludge quantities and its potentially hazardous constituents amounts appear in Tables 3-17, 3-18 and 3-19 for 1974, 1977 and 1983, respectively. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered valid to relate sludge quantities to production for that year. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the pro-

Table 3-12

Category D - Woven Fabric
Dyeing & Finishing
Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Range(1)	Average(2)
Arsenic	0.05	<0.6-<1.4	<1(3)
Barium	1.0	12-85	39
Cadmium	0.01	<1.4-10.8	4.4
Chromium	0.05	89-3,969	1,196
Cobalt	**	<2.8-109	26
Copper	1.0	193-1,130	652
Iron	0.3	917-13,600	4,910
Lead	0.05	<16-68	36
Mangenese	0.05	42-318	128
Mercury	0.002	0.1-0.7	0.35
Molybdenum	**	<0.2-<28	<17
Nickel	**	12-88	32
Zinc	5.0	318-7,791	2,370
Total Heavy Metals			9,412
Aluminum	**	1,420-12,800	4,640
Magnesium	60.0	1,340-5,730	2,820
Potassium	**	1,420-6,350	3,580
Sodium	**	19,400-94,700	51,300
Strontium	**	2.4-21	16
Total Chlorinated Organics	0.7	4.3-27.8	15.2
Suspended Solids (%)	**	0.42-1.34	0.88
Total Solids (%)	**	0.72-2.04	1.26

(1) Range of the individual plant averages
(2) Grand average of 20 measurements from five plants
(3) Less than values were considered to be at the maximum in computing totals
* U.S. Public Health Service. Drinking Water Standards. 1962.
** No drinking water standards have been set for these metals.

Table 3-13. Category D - Estimated Quantities of Total Wastes From Woven Fabric Dyeing and Finishing Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama	1,670	73,282	1,766	79,389	3,638	10,738
X	Alaska						
IX	Arizona						
VI	Arkansas	40	1,631	42	1,734	96	293
IX	California	40	1,631	42	1,734	96	293
VIII	Colorado	20	855	21	926	37	102
I	Connecticut	792	34,617	845	36,650	1,736	5,136
III	Delaware	79	3,462	85	3,665	164	474
IV	Florida	300	13,233	321	14,244	655	1,915
IV	Georgia	3,326	142,675	3,541	152,790	7,290	21,590
IX	Hawaii						
X	Idaho						
V	Illinois	878	38,697	931	40,740	1,904	5,634
V	Indiana	120	5,093	126	5,399	266	790
VII	Iowa						
VII	Kansas	40	1,631	42	1,734	96	293
IV	Kentucky	120	5,093	126	5,399	266	790
VI	Louisiana						
I	Maine	240	9,986	257	10,196	520	1,500
III	Maryland	195	8,552	212	9,263	436	1,296
I	Massachusetts	3,314	142,553	3,429	[illegible]	7,170	21,070
V	Michigan	79	3,362	85	3,565	164	474
V	Minnesota	40	1,631	42	1,734	96	293
IV	Mississippi	79	3,362	85	3,565	164	474
VII	Missouri	60	2,547	63	2,649	132	392
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	212	9,274	229	9,985	468	1,408
II	New Jersey	2,998	132,237	3,213	142,442	6,648	19,548
VI	New Mexico						
II	New York	1,198	50,930	1,263	53,985	2,559	7,499
IV	North Carolina	6,643	275,130	6,973	295,460	14,460	42,560
VIII	North Dakota						
V	Ohio	492	21,384	534	22,406	1,040	3,060
VI	Oklahoma	79	3,362	85	3,565	164	474
X	Oregon						
III	Pennsylvania	177	7,940	194	8,550	375	1,085
I	Rhode Island	177	7,940	194	8,550	375	1,085
IV	South Carolina	10,484	448,140	11,130	478,568	22,460	65,760
VIII	South Dakota						
IV	Tennessee	396	16,313	418	17,335	853	2,493
VI	Texas	813	34,628	866	36,661	1,747	5,147
VIII	Utah						
I	Vermont	79	3,362	85	3,565	164	474
III	Virginia	396	16,313	418	17,335	853	2,493
X	Washington						
III	West Virginia						
V	Wisconsin	40	1,631	42	1,734	132	437
VIII	Wyoming						
TOTAL		35,616	1,522,477	37,702	1,618,203	77,224	227,070
Region	I	4,814	207,732	5,038	211,614	10,433	30,673
	II	4,196	183,167	4,476	196,427	9,207	27,047
	III	847	36,267	909	38,813	1,828	5,348
	IV	23,018	977,228	24,359	1,046,768	49,786	146,320
	V	1,649	71,798	1,760	75,578	3,602	10,688
	VI	932	39,621	992	41,960	2,007	5,914
	VII	100	4,178	105	4,383	228	685
	VIII	20	855	21	926	37	102
	IX	40	1,631	42	1,734	96	293
	X						

Table 3-14. Category D – Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Woven Fabric Dyeing and Finishing Operations, 1974 (KKG/YR) Dry Weight*

		Dye Container■	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	42	0.190	67	3.4	112.59	3.59
X	Alaska						
IX	Arizona						
VI	Arkansas	1	0.005	1.6	0.080	2.685	0.085
IX	California	1	0.005	1.6	0.080	2.685	0.085
VIII	Colorado	0.50	0.002	0.80	0.040	1.342	0.042
I	Connecticut	20	0.092	32	1.6	53.692	1.692
III	Delaware	2	0.009	3.2	0.16	5.369	0.169
IV	Florida	7.5	0.034	12	0.60	20.134	0.634
IV	Georgia	85	0.39	140	6.8	232.19	7.19
IX	Hawaii						
X	Idaho						
V	Illinois	22	0.10	36	1.8	59.9	1.9
V	Indiana	3	0.014	4.8	0.24	8.054	0.254
VII	Iowa						
VII	Kansas	1	0.005	1.6	0.080	2.685	0.085
IV	Kentucky	3	0.014	4.8	0.24	8.054	0.254
VI	Louisiana						
I	Maine	6	0.028	9.6	0.48	16.108	0.508
III	Maryland	5	0.023	8	0.40	13.423	0.423
I	Massachusetts	83	0.38	130	6.6	219.98	6.98
V	Michigan	2	0.009	3.2	0.16	5.369	0.169
V	Minnesota	1	0.005	1.6	0.080	2.685	0.085
IV	Mississippi	2	0.009	3.2	0.16	5.369	0.169
VII	Missouri	1.5	0.007	2.4	0.12	4.027	0.127
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	5.5	0.025	8.8	0.44	14.765	0.465
II	New Jersey	77	0.35	120	6	203.35	6.35
VI	New Mexico						
II	New York	30	0.14	48	2.4	80.54	2.54
IV	North Carolina	170	0.77	270	13	453.77	13.77
VIII	North Dakota						
V	Ohio	12	0.058	20	1	33.058	1.058
VI	Oklahoma	2	0.009	3.2	0.16	5.369	0.169
X	Oregon						
III	Pennsylvania	4.5	0.021	7.2	0.36	12.081	0.381
I	Rhode Island	4.5	0.021	7.2	0.36	12.081	0.381
IV	South Carolina	260	1.2	420	21	702.2	22.2
VIII	South Dakota						
IV	Tennessee	10	0.046	16	0.80	26.846	0.846
VI	Texas	20	0.094	33	1.6	54.694	1.694
VIII	Utah						
I	Vermont	2	0.009	3.2	0.16	5.369	0.169
III	Virginia	10	0.046	16	0.080	26.126	0.126
X	Washington						
III	West Virginia						
V	Wisconsin	1	0.005	1.6	0.080	2.685	74.675
VIII	Wyoming						
TOTAL		897	4.115	1,437.6	70.56	2,409.275	74.675
Region I		121	0.555	190.8	9.64	321.995	10.195
II		107	0.49	168	8.4	283.89	8.89
III		21.5	0.099	34.4	1.0	56.999	1.099
IV		579.5	2.653	933	46	1,561.153	48.653
V		41	0.191	67.2	3.36	111.751	3.551
VI		23	0.108	37.8	1.84	62.748	1.948
VII		2.5	0.012	4	0.200	6.712	0.212
VIII		0.50	0.002	0.80	0.040	1.342	0.042
IX		1	0.005	1.6	0.080	2.685	0.085
X							

* Dry Weight ■ Wet Weight

Table 3-15. Category D – Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Woven Fabric Dyeing and Finishing Operations, 1977 (KKG/YR) Dry Weight*

Region	State	Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	45	0.20	71	3.6	119.8	3.8
X	Alaska						
IX	Arizona						
VI	Arkansas	1.1	0.0053	1.7	0.085	2.8903	0.0903
IX	California	1.1	0.0053	1.7	0.085	2.8903	0.0903
VIII	Colorado	0.53	0.0021	0.85	0.042	1.4241	0.0441
I	Connecticut	21	0.098	34	1.7	5.798	1.798
III	Delaware	2.1	0.010	3.4	0.17	5.68	0.18
IV	Florida	8.0	0.036	13	0.64	21.676	0.676
IV	Georgia	90	0.41	150	7.2	247.61	7.61
IX	Hawaii						
X	Idaho						
V	Illinois	23	0.11	38	1.9	63.01	2.01
V	Indiana	3.2	0.015	5.1	0.25	8.565	0.265
VII	Iowa						
VII	Kansas	1.1	0.0053	1.7	0.085	2.8903	0.0903
IV	Kentucky	3.2	0.015	5.1	0.25	8.565	0.265
VI	Louisiana						
I	Maine	6.4	0.030	10	0.51	16.94	0.54
III	Maryland	5.3	0.024	8.5	0.42	14.244	0.444
I	Massachusetts	88	0.40	140	7.0	235.4	7.4
V	Michigan	2.1	0.0095	3.4	0.17	5.6795	.1795
V	Minnesota	1.1	0.0053	1.7	0.085	2.8903	0.0903
IV	Mississippi	2.1	0.0095	3.4	0.17	5.6795	.1795
VII	Missouri	1.6	0.0074	2.5	0.13	4.2374	0.1374
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	5.8	0.027	9.3	0.47	15.597	0.497
II	New Jersey	82	0.37	130	6.4	218.77	6.77
VI	New Mexico						
II	New York	32	0.15	51	2.5	85.65	2.65
IV	North Carolina	180	0.82	290	14	484.82	14.82
VIII	North Dakota						
V	Ohio	13	0.062	21	1.1	35.162	1.162
VI	Oklahoma	2.1	0.0095	3.4	0.17	5.6795	0.1795
X	Oregon						
III	Pennsylvania	4.8	0.022	7.6	0.38	12.802	0.402
I	Rhode Island	4.8	0.022	7.6	0.38	12.802	0.402
IV	South Carolina	276	1.3	450	22	749.3	23.3
VIII	South Dakota						
IV	Tennessee	11	0.049	17	0.85	28.899	0.899
VI	Texas	21	0.10	35	1.7	57.8	1.8
VIII	Utah						
I	Vermont	2.1	0.0095	3.4	0.17	5.6795	0.1795
III	Virginia	11	0.049	17	0.085	28.134	0.134
X	Washington						
III	West Virginia						
V	Wisconsin	1.1	0.0053	1.7	0.085	2.8903	0.0903
VIII	Wyoming						
TOTAL		952.63	4.393	1,539.05	74.782	2,570.855	79.175
Region I		128.1	0.5865	204.3	10.23	343.2165	10.8165
II		114	0.52	181	8.9	304.42	9.42
III		23.2	0.105	36.5	1.055	60.86	1.16
IV		615.3	2.8395	999.5	48.71	1,666.3495	51.5495
V		43.5	0.2071	70.9	3.59	118.1971	3.7971
VI		24.2	0.1148	40.1	1.955	66.3698	2.0698
VII		2.7	0.0127	4.2	0.215	0.1277	0.2277
VIII		0.53	0.0021	0.85	0.042	1.4241	0.0441
IX		1.1	0.0053	1.7	0.085	2.8903	0.0903
X							

* DRY Weight = Wet Weight

Table 3-16. Category D – Quantities of Potentially Hazardous Dye & Chemical Container Wastes from Woven Fabric Dyeing and Finishing Operations, 1983 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Pot. Hazardous Waste	Total Hazardous Constituents
IV	Alabama	53	0.24	85	4.3	142.54	4.54
X	Alaska						
IX	Arizona						
VI	Arkansas	1.3	0.0063	2.0	0.10	3.4063	0.1063
IX	California	1.3	0.0063	2.0	0.10	3.4063	0.1063
VIII	Colorado	0.63	0.0025	1.0	0.051	1.6835	0.0535
I	Connecticut	25	0.12	41	2.0	68.12	2.12
III	Delaware	2.5	-.-11	4.1	0.20	6.811	0.211
IV	Florida	9.5	0.043	15	0.76	25.303	0.803
IV	Georgia	110	0.49	180	8.6	299.09	9.09
IX	Hawaii						
X	Idaho						
V	Illinois	28	0.13	46	2.3	76.43	2.43
V	Indiana	3.8	0.018	6.1	0.30	10.218	0.318
VII	Iowa						
VII	Kansas	1.3	0.0063	2.0	0.10	3.4063	0.1063
IV	Kentucky	3.8	0.018	6.1	0.30	10.218	0.318
VI	Louisiana						
I	Maine	7.6	0.035	12	0.61	20.245	0.645
III	Maryland	6.3	0.029	10	0.51	16.839	0.539
I	Massachusetts	110	0.48	160	8.4	278.88	8.88
V	Michigan	2.5	0.011	4.1	0.20	6.811	0.211
V	Minnesota	1.3	0.0063	2.0	0.10	3.4063	0.1063
IV	Mississippi	2.5	0.011	4.1	0.20	6.811	0.211
VII	Missouri	1.9	0.0089	3.0	0.15	5.0589	0.1589
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	7.0	0.032	11	0.56	18.592	0.592
II	New Jersey	98	0.44	150	7.6	256.04	8.04
VI	New Mexico						
II	New York	38	0.18	61	3.0	102.18	3.18
IV	North Carolina	220	0.98	340	16	576.98	16.98
VIII	North Dakota						
V	Ohio	15	0.073	25	1.3	41.373	1.373
VI	Oklahoma	2.5	0.011	4.1	0.20	6.811	0.211
X	Oregon						
III	Pennsylvania	5.7	0.027	9.1	0.46	15.287	0.487
I	Rhode Island	5.7	0.027	9.1	0.46	15.287	0.487
IV	South Carolina	330	1.5	530	27	888.5	28.5
VIII	South Dakota						
IV	Tennessee	13	0.058	20	1.0	34.058	1.058
VI	Texas	25	0.12	42	2.0	69.12	2.12
VIII	Utah						
I	Vermont	2.5	0.011	4.1	0.20	6.811	0.211
III	Virginia	13	0.058	20	0.10	33.158	0.158
X	Washington						
III	West Virginia						
V	Wisconsin	1.3	0.0063	2.0	0.10	3.4063	0.1063
VIII	Wyoming						
TOTAL		1148.93	5.1959	1812.9	89.261	3056.2869	94.4569
Region I		157.8	0.705	237.2	12.23	407.935	12.935
II		136	0.62	211	10.6	358.22	11.22
III		27.5	0.125	43.2	1.27	72.095	1.395
IV		741.8	3.34	1180.2	58.16	1983.5	61.5
V		51.9	0.2446	85.2	4.3	141.6446	4.5446
VI		28.8	0.1373	48.1	2.3	79.3373	2.4373
VII		3.2	0.0152	5.0	0.25	8.4652	0.2652
VIII		0.63	0.0025	1.0	0.051	1.6835	0.0535
IX		1.3	0.0063	2.0	0.10	3.4063	0.1063
X							

*Dry Weight = Wet Weight

Table 3-17. Category D - Quantities of Potentially Hazardous Wastewater Treatment Sludges from Woven Fabric Dyeing and Finishing Operations, 1974

		RETAINED SLUDGES[1] (KKG)						WASTED SLUDGES[1] (KKG/YR.					
		Total Dry	Total Wet	Total Heavy Metals ($\times 10^{-3}$)	Total Chlorinated Organics ($\times 10^{-6}$)	Dyestuff ($\times 10^{-3}$)	Total Hazardous Constituents ($\times 10^{-3}$)	Total Dry	Total Wet ($\times 10^{3}$)	Total Heavy Metals	Total Chlorinated Organics ($\times 10^{-3}$)	Dyestuff	Total Hazardous Constituents
IV	Alabama	0.64	73	6.0	9.7	32	38	610	72	5.7	9.1	30	35.7
X	Alaska												
IX	Arizona												
VI	Arkansas	0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
IX	California	0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
VIII	Colorado	0.0076	0.87	0.07	0.11	0.38	0.45	7.2	0.84	0.065	0.11	0.36	0.925
I	Connecticut	0.31	35	2.9	4.7	16	18.9	290	34	2.7	4.4	14	16.7
III	Delaware	0.031	3.5	0.29	0.47	1.6	1.89	29	3.4	0.27	0.44	1.4	1.67
IV	Florida	0.11	13	1.0	1.7	5.5	6.5	110	13	0.13	1.7	5.5	5.63
IV	Georgia	1.3	150	12	20	65	77	1200	140	12	19	60	72
IX	Hawaii												
X	Idaho												
V	Illinois	0.34	39	3.2	5.2	17	20.2	320	38	3.0	4.9	16	19
V	Indiana	0.046	5.2	0.43	0.70	2.3	2.73	44	5.0	0.41	0.65	2.2	2.61
VII	Iowa												
VII	Kansas	0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
IV	Kentucky	0.046	5.2	0.43	0.70	2.3	2.73	44	5.0	0.41	0.65	2.2	2.61
VI	Louisiana												
I	Maine	0.092	10	0.86	1.4	4.6	5.46	84	9.8	0.78	1.3	4.2	4.98
III	Maryland	0.076	8.7	0.70	1.1	3.8	4.5	72	8.4	0.65	1.1	3.6	4.25
I	Massachusetts	1.3	140	12	20	65	77	1200	140	11	18	60	71
V	Michigan	0.031	3.5	0.29	0.47	1.6	1.89	29	3.3	0.27	0.44	1.4	1.67
V	Minnesota	0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
IV	Mississippi	0.031	3.5	0.29	0.47	1.6	1.89	29	3.3	0.27	0.44	1.4	1.67
VII	Missouri	0.023	2.6	0.22	0.35	1.2	1.42	21	2.5	0.20	0.32	1.0	1.2
VIII	Montana												
VII	Nebraska												
IX	Nevada												
I	New Hampshire	0.084	9.6	0.79	1.3	4.2	4.99	78	9.1	0.072	1.2	3.9	3.973
II	New Jersey	1.2	130	11	18	60	71	1100	130	10	17	55	65
VI	New Mexico												
II	New York	0.46	52	4.3	7.0	23	27.3	440	50	4.1	6.5	22	26.1
IV	North Carolina	2.6	290	24	40	130	154	2400	270	23	36	120	143
VIII	North Dakota												
V	Ohio	0.19	22	1.8	2.9	9.5	11.3	180	21	1.7	2.7	9.0	10.7
VI	Oklahoma	0.031	3.5	0.29	0.47	1.6	1.89	29	3.3	0.27	0.44	1.4	1.67
X	Oregon												
III	Pennsylvania	0.069	7.8	0.65	1.0	3.4	4.05	65	7.8	0.61	0.98	3.2	3.81
I	Rhode Island	0.069	7.8	0.65	1.0	3.4	4.05	65	7.8	0.61	0.98	3.2	3.51
IV	South Carolina	4.1	460	38	62	200	238	3800	440	36	58	190	226
VIII	South Dakota												
IV	Tennessee	0.15	17	1.4	2.2	7.5	8.9	140	16	1.3	2.1	7.0	8.3
VI	Texas	0.31	35	2.9	4.7	16	18.9	300	34	2.8	4.6	15	17.8
VIII	Utah												
I	Vermont	0.031	3.5	0.29	0.47	1.6	1.89	29	3.3	0.27	0.44	1.4	1.67
III	Virginia	0.15	17	1.4	2.2	7.5	8.9	140	16	1.3	2.1	7.0	8.3
X	Washington												
III	West Virginia												
V	Wisconsin	0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
VIII	Wyoming												
TOTAL		13.9026	1,556.77	128.85	211.41	691.33	820.18	12,925.2	1,494.84	120,537	196.64	644.86	765.398
Region I		1.886	205.9	17.49	28.87	94.8	112.29	1746	204	15.432	26.32	86.7	102.133
II		1.66	182	15.3	25	83	98.3	1540	180	14.1	23.5	77	91.1
III		0.326	37	3.04	4.77	16.3	19.34	306	35.6	2.83	4.62	15.2	18.0
IV		8.977	1,011.7	83.12	136.77	443.9	527.02	8333	959.3	78.81	126.99	416.1	494.91
V		0.637	73.1	6.0	9.71	31.9	37.9	601	70.5	5.64	9.11	30	35.64
VI		0.356	40.2	3.33	5.39	18.35	21.68	343	38.9	3.2	5.25	17.1	20.3
VII		0.038	4.3	0.36	0.57	1.95	2.31	35	4.1	0.33	0.53	1.7	2.03
VIII		0.0076	0.87	0.07	0.11	0.38	0.45	7.2	0.84	0.065	0.11	0.36	0.425
IX		0.015	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
X													

[1] See Table 3-8 for definition of retained and wasted sludge.

Table 3-18. Category D – Quantities of Potentially Hazardous Wastewater Treatment Sludges from Woven Fabric Dyeing and Finishing Operations, 1977

Region	State	Retained Sludges[1] (KKG): Total Dry	Retained: Total Wet	Retained: Total Heavy Metals (x 10^{-3})	Retained: Total Chlorinated Organics (x 10^{-6})	Retained: Dyestuff (x 10^{-3})	Retained: Total Hazardous Constituents (x 10^{-3})	Wasted Sludges[1] (KKG/YR): Total Dry	Wasted: Total Wet (x 10^{3})	Wasted: Total Heavy Metals	Wasted: Total Chlorinated Organics (x 10^{-3})	Wasted: Dyestuff	Wasted: Total Hazardous Constituents
IV	Alabama	0.64	73	6.0	9.7	32	38	650	78	6.0	9.8	32	38
X	Alaska												
IX	Arizona												
VI	Arkansas	0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
IX	California	0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
VIII	Colorado	0.0076	0.87	0.07	0.11	0.38	0.45	7.8	0.91	0.072	0.12	0.39	0.462
I	Connecticut	0.31	35	2.9	4.7	16	18.9	310	36	2.9	4.7	16	18.9
III	Delaware	0.031	3.5	0.29	0.47	1.6	1.89	31	3.6	0.29	0.47	1.6	1.89
IV	Florida	0.11	13	1.0	1.7	5.5	6.5	120	14	1.1	1.8	6.0	7.1
IV	Georgia	1.3	150	12	20	65	77		150	12	20	65	77
IX	Hawaii												
X	Idaho												
V	Illinois	0.34	39	3.2	5.2	17	20.2	340	40	3.2	5.3	17	20.2
V	Indiana	0.046	5.2	0.43	0.70	2.3	2.73	46	5.3	0.44	0.72	2.3	2.74
VII	Iowa												
VII	Kansas	0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
IV	Kentucky	0.046	5.2	0.43	0.70	2.3	2.73	46	5.3	0.44	0.72	2.3	2.74
VI	Louisiana												
I	Maine	0.092	10	0.86	1.4	4.6	5.46	91	10	0.84	1.4	4.6	5.44
III	Maryland	0.076	8.7	0.70	1.1	3.8	4.5	78	9.1	0.72	1.2	3.9	4.62
I	Massachusetts	1.3	140	12	20	65	77		140	12	19	60	72
V	Michigan	0.031	3.5	0.29	0.47	1.6	1.89	31	3.5	0.28	0.46	1.5	1.78
V	Minnesota	0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
IV	Mississippi	0.031	3.5	0.29	0.47	1.6	1.89	30	3.5	0.28	0.46	1.5	1.78
VII	Missouri	0.023	2.6	0.22	0.35	1.2	1.42	23	2.6	0.21	0.34	1.2	1.41
VIII	Montana												
VII	Nebraska												
IX	Nevada												
I	New Hampshire	0.084	9.6	0.79	1.3	4.2	4.99	84	9.8	0.078	1.2	4.2	4.279
II	New Jersey	1.2	130	11	18	60	71	1200	140	11	18	60	71
VI	New Mexico												
II	New York	0.46	52	4.3	7.0	23	27.3	460	53	4.4	7.2	23	27.4
IV	North Carolina	2.6	290	24	40	130	154	2500	290	24	38	125	149
VIII	North Dakota												
V	Ohio	0.19	22	1.8	2.9	9.5	11.3	200	22	1.8	2.9	10	11.8
VI	Oklahoma	0.031	3.5	0.29	0.47	1.6	1.89	30	3.5	0.28	0.46	1.5	1.78
X	Oregon												
III	Pennsylvania	0.069	7.8	0.65	1.0	3.4	4.05	72	8.4	0.65	1.0	3.6	4.25
I	Rhode Island	0.069	7.8	0.65	1.0	3.4	4.05	72	8.4	0.65	1.0	3.6	4.25
IV	South Carolina	4.1	460	38	62	200	238	4000	470	38	62	200	238
VIII	South Dakota												
IV	Tennessee	0.15	17	1.4	2.2	7.5	8.9	150	17	1.4	2.3	7.5	8.9
VI	Texas	0.31	35	2.9	4.7	16	18.9	320	36	3.0	4.8	16	19
VIII	Utah												
I	Vermont	0.031	3.5	0.29	0.47	1.6	1.89	30	3.5	0.28	0.46	1.5	1.78
III	Virginia	0.15	17	1.4	2.2	7.5	8.9	150	17	1.4	2.3	7.5	8.9
X	Washington												
III	West Virginia												
V	Wisconsin	0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
VIII	Wyoming												
TOTAL		13.9026	1,556.77	128.85	211.41	691.33	820.18	13,646.8	1,588.91	128.41	209.26	682.44	810.851
Region I		1.886	205.9	17.49	28.87	94.8	112.29	1,787	207.7	16.748	27.76	89.9	106.649
II		1.66	182	15.3	25	83	98.3	1,660	193	15.4	25.2	83	98.42
III		0.326	37	3.04	4.77	16.3	19.34	331	38.1	3.06	4.97	16.6	19.66
IV		8.977	1,011.7	83.12	136.77	443.9	527.02	8,796	1,027.8	83.22	135.08	439.3	522.52
V		0.637	73.1	6.0	9.71	31.9	37.9	647	74.2	6.0	9.84	32.3	38.3
VI		0.356	40.2	3.33	5.39	18.35	21.68	365	41.2	3.42	5.49	18.25	21.67
VII		0.038	4.3	0.36	0.57	1.95	2.31	38	4.3	0.35	0.57	1.95	2.3
VIII		0.0076	0.87	0.07	0.11	0.38	0.45	7.8	0.91	0.072	0.12	0.39	0.462
IX		0.015	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
X													

[1] See Table 3-8 for definition of retained and wasted sludge.

Table 3-19. Category D – Quantities of Potentially Hazardous Wastewater Treatment Sludges From Woven Fabric Dyeing and Finishing Operations,* 1983 (KKG/YR)

		Total Potentially Hazardous Waste		Total Heavy Metals	Total Chlorinated Organics ($\times 10^{-3}$)	Dyestuff	Total Hazardous Constituents
		Dry	Wet ($\times 10^{3}$)				
IV	Alabama	2300	9.2	21	34	120	141
X	Alaska						
IX	Arizona						
VI	Arkansas	64	0.256	0.60	0.98	3.2	3.8
IX	California	64	0.256	0.60	0.98	3.2	3.8
VIII	Colorado	21	0.084	0.20	0.32	1.0	1.2
I	Connecticut	1,100	4.4	10	17	55	65
III	Delaware	100	0.4	0.98	1.6	5.0	5.98
IV	Florida	410	1.64	3.8	6.2	20	23.8
IV	Georgia	4,600	18.4	44	72	230	274
IX	Hawaii						
X	Idaho						
V	Illinois	1,200	4.8	12	19	60	72
V	Indiana	170	0.68	1.6	2.6	8.5	10.1
VII	Iowa						
VII	Kansas	64	0.256	0.60	0.98	3.2	3.8
IV	Kentucky	170	0.68	1.6	2.6	8.5	10.1
VI	Louisiana						
I	Maine	320	1.28	3.0	4.9	16	19
III	Maryland	280	1.12	2.6	4.2	14	16.6
I	Massachusetts	4,500	18	42	65	220	262
V	Michigan	100	0.4	0.98	1.6	5.0	5.98
V	Minnesota	64	0.256	0.60	0.98	3.2	3.8
IV	Mississippi	100	0.4	0.98	1.6	5.0	5.98
VII	Missouri	84	0.336	0.78	1.3	4.2	4.98
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	300	1.2	2.8	4.6	15	17.8
II	New Jersey	4,200	16.8	39	63	210	249
VI	New Mexico						
II	New York	1,600	6.4	15	25	80	95
IV	North Carolina	9,100	36.4	84	140	460	544
VIII	North Dakota						
V	Ohio	650	2.6	6.0	9.8	32	38
VI	Oklahoma	100	0.4	0.98	1.6	5.0	5.98
X	Oregon						
III	Pennsylvania	230	0.92	2.2	3.6	12	14.2
I	Rhode Island	230	0.92	2.2	3.6	12	14.2
IV	South Carolina	14,000	56	140	210	700	840
VIII	South Dakota						
IV	Tennessee	530	2.12	5.0	7.8	26	31
VI	Texas	1,100	4.4	10	17	55	65
VIII	Utah						
I	Vermont	100	0.4	0.98	1.6	5.0	5.98
III	Virginia	530	2.12	5.0	7.8	26	31
X	Washington						
III	West Virginia						
V	Wisconsin	100	0.4	0.98	116	5.0	5.98
VIII	Wyoming						
TOTAL		48,481	193,924	462.06	734.84	2,428	2,890.06
Region	I	6,550	26.2	60.98	96.7	323	383.98
	II	5,800	23.2	54	88	290	344
	III	1,140	4.56	10.78	17.2	57	67.78
	IV	31,210	124.84	300.38	474.2	1,569.5	1,869.88
	V	2,284	9.136	22.16	35.58	113.7	135.86
	VI	1,264	5.056	11.58	19.58	63.2	74.78
	VII	148	0.592	1.38	2.28	7.4	8.78
	VIII	21	0.084	0.20	0.32	1.0	1.2
	IX	64	0.256	0.60	0.98	3.2	3.8
	X						

*It was not possible to differentiate between the retained and wasted sludge for 1983 so the estimated values for this year reflect the total quantity.

jected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

3.4.5 Category E - Knit Fabric Dyeing and Finishing

The 20 plants visited in this category are located in Alabama, Massachusetts, New York, North Carolina, Pennsylvania, South Carolina, Tennessee and Virginia. Their annual productions range from 380 to 19,000 metric tons. The typical plant with wastewater treatment facilities produces 4,000 metric tons annually. The number of employees involved in wet processing at the 20 plants range from 110 to 800, and average 390. One plant, fully integrated from raw fiber to finished garments, employs 5,000 people. However, only 500 are involved in wet processing as contrasted with 2,500 involved in sewing operations. Equipment is newer in this category than in Category D (Woven Fabric Dyeing and Finishing) as illustrated below:

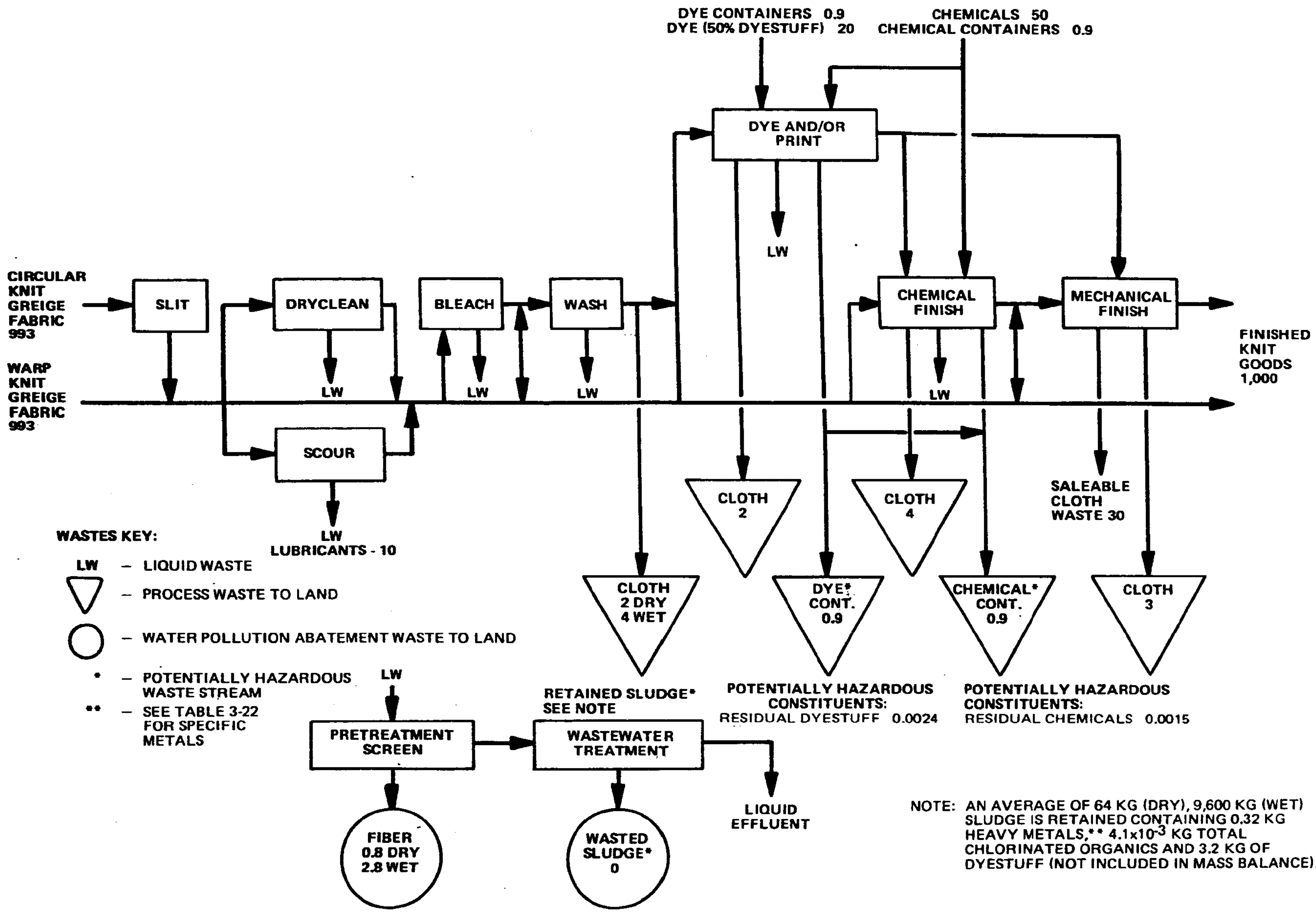
No. of Plants with Equipment Ages	Category E	Category D
less than 5 years	4	0
6 to 20 years	10	10
greater than 20 years	6	12

This is to be expected, because of the relatively recent introduction and popularization of knit (especially double knit) fabrics. Operations normally run 3 shifts per day, 5 to 7 days per week, 50 weeks per year.

3.4.5.1 Process Description

A mass balanced flow diagram of the "typical" knit fabric dyeing and finishing process is shown in Figure 3-5. The knit industry is undoubtedly the most diversified category, in terms of products and processes, of all seven of the industry categories. The various types of knitted items range from hosiery and pantyhose, underwear and outerwear to circular and warp knits. The reader should be cautioned that, while the descriptions of the process flow and waste streams are sufficient for the purposes of this report, it is more likely that, in reality, there may be as many "typical" knit dyeing and finishing process descriptions as there are plants in this category. Figure 3-5 presents a generalized overview of the entire category, and its use for purposes other than those delineated for this report may be misleading. Of the 20 plants reviewed, no two plants performed the same operations in the same sequence. Individual operations are addressed below.

Figure 3-5. CATEGORY E - TYPICAL KNIT FABRIC DYEING AND FINISH PROCESS



Slit. Circular knit fabric (fabric in a tubular form) may be slit and opened to flat form at virtually any point in the process, depending on requirements of the processing equipment (i.e., if the equipment is not capable of handling fabric in a tubular form, it must be slit and opened to flat form). At three of the plants processing circular knit goods, slitting was the first stage of the operation.

Dryclean. This operation is included for the sake of completeness. It is not, however, a very extensively used process (two of the 20 plants - or 10 percent - drycleaned only a portion of their output) and is normally performed only on yarn-dyed fabrics knit of 100 per cent synthetic yarns.

Scour. Natural waxes, lubricants, or tints applied to the yarn for identification purposes are removed in this operation to prepare the fabric for dyeing.

Bleach and Wash. Fabric which is to remain white or to be dyed very light shades is bleached and then washed to remove excess bleaching chemicals.

Dye and/or Print. Fabrics which are to be dyed go to a dye beck, jig, or continuous dye range, where an average amount of dye equivalent to 2 percent of the weight of the fabric is used in the bath. If the cloth was woven from pre-dyed yarn, or if the cloth was bleached and is to remain white, this operation would be bypassed. White or dyed fabrics which are to be printed may be flat-bed printed, or rotary screen printed. For detailed information on dyeing and printing techniques and equipment, the reader is referred to the two sections of the glossary (Appendix A) entitled "dyeing" and "printing".

Chemical Finish. Chemical finishes such as anti-statics, anti-soils, fire retardants, softeners, water repellents and permanent press resins may be applied. Additionally, fabrics may be bonded together in this step. This process may be bypassed altogether, or be either preceded or followed by mechanical finishing.

Mechanical Finish. Brushing, napping, pressing, tentering, heat setting and calendering are common mechanical finishing operations which remove wrinkles, improve the hand of the cloth, its dimensional stability or shrinkage characteristics, or alter its surface characteristics. The cloth may pass through any one or usually several of these operations. Mechanical finishing may be bypassed altogether or either preceded or followed by chemical finishing.

3.4.5.2 Waste Stream Descriptions *

This category's typical plant land-destined waste streams are:

Waste	Source	Quantity (kg of waste/ kkg of product)
cloth	dye and/or print	2
cloth	chemical finish	4
cloth	mechanical finish	3
dye containers	dye and/or print	0.9
chemical containers	dye and/or print and chemical finish	0.9
cloth	wash	2 (dry) 4 (wet)
fiber	wastewater pretreatment screening	0.8 (dry) 2.8 (wet)
wasted sludge	wastewater treatment	typically none
retained sludge*	wastewater treatment	64 kg (dry) 9,600 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

3.4.5.2.1 Potentially Hazardous or Non-Hazardous Constituents

The fiber and cloth wastes identified in Figure 3-5 are considered non-hazardous. The dye and chemical container waste streams are considered potentially hazardous because they contain hazardous residual dyestuff and chemicals. The potentially hazardous portions of the dye container and chemical container waste streams were determined to be 0.0024 kg/kkg of product and 0.0015 kg/kkg of product, respectively.

Sludges retained in the wastewater treatment system (typically, no sludges are currently disposed) also contain hazardous constituents such as heavy metals (copper, zinc), chlorinated organics and dyestuff, and therefore, are also considered potentially hazardous.

3.4.5.2.2 Sampling Results

Table 3-20 lists the results of the laboratory analyses performed on composite sludge samples taken weekly over a period of four weeks from three plants. In every instance where drinking water limits are established, metals or chlorinated organics concentrations exceed these limits. Iron accounted for 76 per cent by weight of the total heavy metals content of the sludge. Analysis performed for total chlorinated organics showed 99.4 per cent by weight of the total content (64.7 ppm) was found in the solid phase of the sludge, with the remainder in the liquid phase. Total chlorinated organics concentrations in this category were the highest of all categories. This may be due in part to their use as dye dispersants in dyeing the synthetic fibers which are commonly

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Table 3-20

Category E - Knit Fabric
Dyeing & Finishing
Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Range(1)	Average(2)
Arsenic	0.55	<0.85-<12	<4.8(3)
Barium	1.0	<15-<125	<53
Cadmium	0.01	<0.7-< 12	< 4.5
Chromium	0.05	2.5-50.2	33
Cobalt	**	<3.7- 62	<23
Copper	1.0	89-1,030	410
Iron	0.3	1,557-8,260	3,840
Lead	0.05	<7-<125	<52
Manganese	0.05	12.6-112	51
Mercury	0.002	0.7-1.9	1.4
Molybdenum	**	<15-<250	<94
Nickel	**	<3.7-<62	<25
Zinc	5.0	120-1,250	550
Total Heavy Metals			5,117
Aluminum	**	1,293-6,625	3,180
Magnesium	60.0	963-1,625	1,210
Potassium	**	1,560-4,040	2,850
Sodium	**	12,800-87,500	54,200
Strontium	**	3.7-<38	15
Total Chlorinated Organics	0.7	2.24-181	64.7
Suspended Solids (%)	**	0.02-1.1	0.69
Total Solids (%)	**	0.08-1.35	0.87

(1) Range of the individual plant averages
(2) Grand average of 12 measurements from three plants
(3) Less than values were considered to be at the maximum in computing totals
* U.S. Public Health Service. Drinking Water Standards. 1962
** No drinking water standards have been set for these metals

processed in this category. Detailed sampling results may be found in Appendix C of this report.

An average of 64 kg (dry) or 9,600 kg (wet) of sludge is retained in the typical plant's wastewater treatment system, containing 0.32 kg of total heavy metals, 4.1×10^{-3} kg of total chlorinated organics, and 3.2 kg of dyestuff.

3.4.5.3 Waste Quantities for 1974, 1977 and 1983

Because products in this category are ultimately used for apparel, furnishings and other consumer products, waste projections are closely related to population growth. (A growth factor of 3 per cent per annum was applied.) Table 3-21 quantifies the total wastes for this category for 1974, 1977 and 1983.

Tables 3-22, 3-23 and 3-24 list dye and chemical container and potentially hazardous container residuals wastes for 1974, 1977 and 1983, respectively.

Sludge quantities and its potentially hazardous constituents amounts appear in Tables 3-25, 3-26 and 3-27 for 1974, 1977 and 1983, respectively. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered valid to relate sludge quantities to production for that year. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

3.4.6 Category F - Carpet Mills

The eleven tufted carpet dyeing and finishing plants visited in this category are located in California, Georgia, North Carolina and South Carolina. Their annual productions range from 4,000 to 70,000 metric tons. The typical plant with wastewater treatment facilities produces 10,000 metric tons annually. The number of employees at the eleven plants range from 55 to 900 and average 345. Eight of the eleven plants' equipment ages are in the 5 to 30 year bracket, with one plant's equipment newer and two plants' equipment older than this. Operations normally run 3 shifts per day, 5 to 7 days per week, 50 weeks per year.

Table 3-21. Category E - Estimated Quantities of Total Waste from Knit Fabric Dyeing and Finishing Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama	404	510	428	537	1,908	6,188
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	150	187	162	200	706	2,296
VIII	Colorado						
I	Connecticut	68	86	72	91	306	978
III	Delaware						
IV	Florida	138	173	149	185	662	2,162
IV	Georgia	484	619	508	656	2,412	7,912
IX	Hawaii						
X	Idaho	14	17	15	19	54	168
V	Illinois	54	68	58	72	259	839
V	Indiana						
VII	Iowa	28	35	29	37	145	480
VII	Kansas						
IV	Kentucky	82	103	86	109	404	1,314
VI	Louisiana	40	51	43	54	201	658
I	Maine	14	17	15	19	54	168
III	Maryland	14	17	15	19	54	168
I	Massachusetts	208	261	220	274	986	3,186
V	Michigan	14	17	15	19	54	168
V	Minnesota	68	86	72	91	306	978
IV	Mississippi	54	68	58	72	259	839
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	68	86	72	91	306	978
II	New Jersey	542	683	576	721	2,592	8,392
VI	New Mexico						
II	New York	957	1,206	1,015	1,254	4,360	14,160
IV	North Carolina	4,163	5,340	4,404	5,710	20,300	66,100
VIII	North Dakota						
V	Ohio	54	68	58	72	259	839
VI	Oklahoma	14	17	15	19	54	168
X	Oregon	14	17	15	19	54	168
III	Pennsylvania	887	1,116	945	1,184	4,226	13,646
I	Rhode Island	126	150	137	162	570	1,810
IV	South Carolina	819	1,030	865	1,092	3,936	12,736
VIII	South Dakota						
IV	Tennessee	518	646	552	684	2,456	7,946
VI	Texas	54	68	58	72	259	839
VIII	Utah						
I	Vermont	14	17	15	19	54	168
III	Virginia	288	360	300	384	1,348	4,338
X	Washington						
III	West Virginia	14	17	15	19	54	168
V	Wisconsin	82	103	86	109	404	1,314
VIII	Wyoming						
TOTAL		10,448	13,239	11,073	14,065	50,002	162,272
Region I		498	617	531	656	2,276	7,288
II		1,499	1,889	1,591	1,975	6,952	22,552
III		1,203	1,510	1,275	1,606	5,682	18,320
IV		6,662	8,489	7,050	9,045	32,337	105,197
V		272	342	289	363	1,282	4,138
VI		108	136	116	145	514	1,665
VII		28	35	29	37	145	480
VIII							
IX		150	187	162	200	706	2,296
X		28	35	30	38	108	336

Table 3-22. Category E – Quantities of Potentially Hazardous Dye and Chemical Container Wastes From Knit Fabric Dyeing and Finishing Operations, 1974 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Pot. Hazardous Waste	Total Hazardous Constituents
IV	Alabama	27	0.072	27	0.045	54.117	0.117
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	9.9	0.026	9.9	0.016	19.842	0.042
VIII	Colorado						
I	Connecticut	4.5	0.012	4.5	0.008	9.02	0.02
III	Delaware						
IV	Florida	9	0.024	9	0.015	18.039	0.039
IV	Georgia	32	0.086	32	0.054	64.14	0.14
IX	Hawaii						
X	Idaho	0.90	0.002	0.90	0.002	1.804	0.004
V	Illinois	3.6	0.010	3.6	0.006	7.216	0.016
V	Indiana						
VII	Iowa	1.8	0.005	1.8	0.003	3.608	0.008
VII	Kansas						
IV	Kentucky	5.4	0.014	5.4	0.009	10.823	0.023
VI	Louisiana	2.7	0.007	2.7	0.004	5.411	0.011
I	Maine	0.90	0.002	0.90	0.002	1.804	0.004
III	Maryland	0.90	0.002	0.90	0.002	1.804	0.004
I	Massachusetts	14	0.036	14	0.022	28.058	0.058
V	Michigan	0.90	0.002	0.90	0.002	1.804	0.004
V	Minnesota	5.4	0.012	4.5	0.008	9.02	0.02
IV	Mississippi	3.6	0.010	3.6	0.006	7.216	0.016
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	4.5	0.012	4.5	0.008	9.02	0.02
II	New Jersey	36	0.096	36	0.060	72.156	0.156
VI	New Mexico						
II	New York	63	0.17	63	0.10	126.27	0.27
IV	North Carolina	280	0.74	280	0.46	561.2	1.2
VIII	North Dakota						
V	Ohio	3.6	0.010	3.6	0.006	7.216	0.016
VI	Oklahoma	9.90	0.002	0.90	0.002	18.04	0.004
X	Oregon	0.90	0.002	0.90	0.002	18.04	0.004
III	Pennsylvania	58	0.16	58	0.098	116.258	0.258
I	Rhode Island	8.1	0.022	8.1	0.014	16.236	0.036
IV	South Carolina	54	0.14	54	0.090	108.23	0.23
VIII	South Dakota						
IV	Tennessee	34	0.091	34	0.057	68.148	0.148
VI	Texas	3.6	0.010	3.6	0.006	7.216	0.016
VIII	Utah						
I	Vermont	0.90	0.002	0.90	0.002	1.804	0.004
III	Virginia	19	0.050	19	0.032	38.082	0.082
X	Washington						
III	West Virginia	0.90	0.002	0.90	0.002	1.804	0.004
V	Wisconsin	5.4	0.014	5.4	0.009	10.823	0.023
VIII	Wyoming						
TOTAL		694.4	1.845	694.4	1.152	1,391.797	2.997
Region I		32.9	0.086	32.9	0.056	65.942	0.142
II		99	0.266	99	0.16	198.426	0.426
III		78.8	0.214	78.8	0.134	157.948	0.348
IV		445	1.177	445	0.736	891913	1.913
V		18	0.048	18	0.031	36.079	0.079
VI		7.2	0.019	7.2	0.012	14.431	0.031
VII		1.8	0.005	1.8	0.003	3.608	0.008
VIII							
IX		9.9	0.026	9.9	0.016	19.842	0.042
X		1.8	0.004	1.8	0.004	3.608	0.008

*Dry Weight = Wet Weight

Table 3-23. Category E – Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Knit Fabric Dyeing and Finishing Operations, 1977 (KKG/YR) Dry Weight*

Region	State	Dye Container	Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Pot. Hazardous Waste	Total Hazardous Constituents
IV	Alabama	29	0.076	29	0.048	58.124	0.124
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	11	0.028	11	0.017	22.045	0.045
VIII	Colorado						
I	Connecticut	4.8	0.013	4.8	0.0085	9.6215	0.0215
III	Delaware						
IV	Florida	9.5	0.025	9.5	0.016	19.041	0.041
IV	Georgia	34	0.091	34	0.057	68.148	0.148
IX	Hawaii						
X	Idaho	0.095	0.0021	0.095	0.0021	0.1942	0.0042
V	Illinois	3.8	0.011	3.8	0.0064	7.6174	0.0174
V	Indiana						
VII	Iowa	1.9	0.0053	1.9	0.0032	3.8085	0.0085
VII	Kansas						
IV	Kentucky	5.7	0.015	5.7	0.0095	11.4245	0.0245
VI	Louisiana	2.9	0.0074	2.9	0.0042	5.8116	0.0116
I	Maine	0.95	0.0021	0.95	0.0021	1.9042	0.0042
III	Maryland	0.95	0.0021	0.95	0.0021	1.9042	0.0042
I	Massachusetts	15	0.038	15	0.023	30.061	0.061
V	Michigan	0.95	0.0021	0.95	0.0021	1.9042	0.0042
V	Minnesota	4.8	0.013	4.8	0.0085	9.6215	0.0215
IV	Mississippi	3.8	0.011	3.8	0.0064	7.6174	0.0174
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	4.8	0.013	4.8	0.0085	9.6215	0.0215
II	New Jersey	38	0.10	38	0.064	76.164	0.164
VI	New Mexico						
II	New York	67	0.18	67	0.11	134.29	0.29
IV	North Carolina	300	0.78	300	0.49	601.27	1.27
VIII	North Dakota						
V	Ohio	3.8	0.011	3.8	0.0064	7.6174	0.0174
VI	Oklahoma	0.95	0.0021	0.95	0.0021	1.9042	0.0042
X	Oregon	0.95	0.0021	0.95	0.0021	1.9042	0.0042
III	Pennsylvania	62	0.17	62	0.10	124.27	0.27
I.	Rhode Island	8.6	0.023	8.6	0.015	17.238	0.038
IV	South Carolina	57	0.15	57	0.095	114.245	0.245
VIII	South Dakota						
IV	Tennessee	36	0.096	36	0.060	72.156	0.156
VI	Texas	3.8	0.011	3.8	0.0064	7.6174	0.0174
VIII	Utah						
I	Vermont	0.95	0.0021	0.95	0.0021	1.9042	0.0042
III	Virginia	20	0.053	20	0.034	40.087	0.087
X	Washington						
III	West Virginia	0.95	0.0021	0.95	0.0021	1.9042	0.0042
V	Wisconsin	5.7	0.015	5.7	0.0095	11.4245	0.0245
VIII	Wyoming						
TOTAL		739.645	1.9525	739.645	1.2233	1,482.4658	3.1758
Region I		35.1	0.0912	35.1	0.0592	70.3504	0.1504
II		105	0.28	105	0.174	210.454	0.454
III		83.9	0.2272	83.9	0.1382	168.1654	0.3654
IV		475	1.244	475	0.7819	952.0259	2.0259
V		19.05	0.0521	19.05	0.0329	38.185	0.085
VI		7.65	0.0205	7.65	0.0127	15.3332	0.0332
VII		1.9	0.0053	1.9	0.0032	3.8085	0.0085
VIII							
IX		11	0.028	11	0.017	22.045	0.045
X		1.045	0.0042	1.045	0.0042	2.0984	0.0084

*Dry Weight = Wet Weight

Table 3-24. Category E - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Knit Fabric Dyeing and Finishing Operations, 1983 (KKG/YR) Dry Weight*

		Dye Container	Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	34	0.091	34	0.057	68.148	0.148
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	13	0.033	13	0.020	26.053	0.053
VIII	Colorado						
I	Connecticut	5.7	0.015	5.7	0.010	11.425	0.025
III	Delaware						
IV	Florida	11	0.030	11	0.019	22.049	0.049
IV	Georgia	41	0.11	41	0.068	82.178	0.178
IX	Hawaii						
X	Idaho	1.1	0.0025	1.1	0.0025	2.205	0.0050
V	Illinois	4.6	0.013	4.6	0.0076	9.2206	0.0206
V	Indiana						
VII	Iowa	2.3	0.0063	2.3	0.0038	4.6101	0.0101
VII	Kansas						
IV	Kentucky	6.8	0.018	6.8	0.011	13.629	0.029
VI	Louisiana	3.4	0.0089	3.4	0.0051	6.814	0.014
I	Maine	1.1	0.0025	1.1	0.0025	2.205	0.0050
III	Maryland	1.1	0.0025	1.1	0.0025	2.205	0.0050
I	Massachusetts	18	0.046	18	0.028	36.074	0.074
V	Michigan	1.1	0.0025	1.1	0.0025	2.205	0.0050
V	Minnesota	5.7	0.015	5.7	0.010	11.425	0.025
IV	Mississippi	4.6	0.013	4.6	0.0076	9.2206	0.0206
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	5.7	0.015	5.7	0.010	11.425	0.025
II	New Jersey	46	0.12	46	0.076	92.196	0.196
VI	New Mexico						
II	New York	80	0.22	80	0.13	160.35	0.35
IV	North Carolina	350	0.94	350	0.58	701.52	1.52
VIII	North Dakota						
V	Ohio	4.6	0.013	4.6	0.0076	9.2206	0.0206
VI	Oklahoma	1.1	0.0025	1.1	0.0025	2.205	0.0050
X	Oregon	1.1	0.0025	1.1	0.0025	2.205	0.0050
III	Pennsylvania	73	0.20	73	0.12	146.32	0.32
I	Rhode Island	10	0.028	10	0.018	20.046	0.046
IV	South Carolina	68	0.18	68	0.11	136.29	0.29
VIII	South Dakota						
IV	Tennessee	43	0.12	43	0.072	86.192	0.192
VI	Texas	4.6	0.013	4.6	0.0076	9.2206	0.0206
VIII	Utah						
I	Vermont	1.1	0.0025	1.1	0.0025	2.205	0.0050
III	Virginia	24	0.063	24	0.041	48.104	0.104
X	Washington						
III	West Virginia	1.1	0.0025	1.1	0.0025	2.205	0.0050
V	Wisconsin	6.8	0.018	6.8	0.011	13.629	0.029
VIII	Wyoming						
TOTAL		874.6	2.3492	874.6	1.4503	1,752.9995	3.7995
Region I		41.6	0.109	41.6	0.071	83.38	0.18
II		126	0.34	126	0.206	252.546	0.546
III		99.2	0.268	99.2	0.166	198.834	0.546
IV		558.4	1.502	558.4	0.9246	1,119.2266	2.4266
V		22.8	0.0615	22.8	0.0387	45.7002	0.1002
VI		9.1	0.0244	9.1	0.0152	18.2396	0.0396
VII		2.3	0.0063	2.3	0.0038	4.6101	0.0101
VIII							
IX		13	0.033	13	0.020	26.053	0.053
X		2.2	0.005	2.2	0.005	4.41	0.010

* Dry Weight = Wet Weight

Table 3-25. Category E - Knit Fabric Dyeing and Finishing Wastewater Treatment Sludges, 1974

		RETAINED SLUDGES (KKG)* (NO WASTED SLUDGES)					
		Total Dry	Total Wet	Total Heavy Metals (x 10^{-3})	Total Chlorinated Organics (x 10^{-6})	Dyestuff (x 10^{-3})	Total Hazardous Constituents (x 10^{-3})
IV	Alabama	0.32	46	1.6	21	16	17.6
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	0.12	17	0.60	7.8	6	6.6
VIII	Colorado						
I	Connecticut	0.053	7.7	0.27	3.4	2.7	2.97
III	Delaware						
IV	Florida	0.10	15	0.50	6.5	5	5.5
IV	Georgia	0.36	55	1.8	23	18	19.8
IX	Hawaii						
X	Idaho	0.010	1.5	0.05	0.65	0.50	0.55
V	Illinois	0.042	6.1	0.21	2.7	2.1	2.31
V	Indiana						
VII	Iowa	0.021	3.0	0.10	1.4	1.0	1.1
VII	Kansas						
IV	Kentucky	0.063	9.2	0.32	4.1	3.2	3.52
VI	Louisiana	0.032	4.6	0.16	2.1	1.6	1.76
I	Maine	0.010	1.5	0.05	0.65	0.50	0.55
III	Maryland	0.010	1.5	0.05	0.65	0.50	0.55
I	Massachusetts	0.16	23	0.80	10	8.0	8.8
V	Michigan	0.010	1.5	0.05	0.65	0.50	0.55
V	Minnesota	0.053	7.7	0.27	3.4	2.7	2.97
IV	Mississippi	0.042	6.1	0.21	2.7	2.1	2.31
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	0.053	7.7	0.27	3.4	2.7	2.97
II	New Jersey	0.42	61	2.1	27	21	23.1
VI	New Mexico						
II	New York	0.74	110	3.7	48	37	40.7
IV	North Carolina	3.3	480	16	210	160	176
VIII	North Dakota						
V	Ohio	0.042	6.1	0.21	2.7	2.1	2.31
VI	Oklahoma	0.010	1.5	0.05	0.65	0.50	0.55
X	Oregon	0.010	1.5	0.05	0.65	0.50	0.55
III	Pennsylvania	0.69	100	3.5	45	35	38.5
I	Rhode Island	0.095	14	0.48	6.1	4.8	5.28
IV	South Carolina	0.63	92	3.2	41	32	35.2
VIII	South Dakota						
IV	Tennessee	0.40	58	2.0	26	20	22
VI	Texas	0.042	6.1	0.21	2.7	2.1	2.31
VIII	Utah						
I	Vermont	0.010	1.5	0.05	0.65	0.50	0.55
III	Virginia	0.22	32	1.1	14	11	12.1
X	Washington						
III	West Virginia	0.010	1.5	0.05	0.65	0.50	0.55
V	Wisconsin	0.063	9.2	0.32	4.1	3.2	3.52
VIII	Wyoming						
TOTAL		8.141	1188.5	40.33	523.3	403.3	443.6
Region I		0.381	55.4	1.92	24.2	19.2	21.1
II		1.16	171	5.8	75	58	63.8
III		0.93	135	4.7	60.3	47	51.7
IV		5.215	761.3	25.63	334.3	256.3	281.9
V		0.21	30.6	1.06	13.55	10.6	11.66
VI		0.084	12.2	0.42	5.45	4.2	4.62
VII		0.021	3.0	0.10	1.4	1.0	1.1
VIII							
IX		0.12	17	0.60	7.8	6.0	6.6
X		0.02	3.0	0.10	1.3	1.0	1.1

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-26. Category E - Knit Fabric Dyeing and Finishing Wastewater Treatment Sludges, 1977

		RETAINED SLUDGES (KKG) * (NO WASTED SLUDGES)					
		Total Dry	Total Wet	Total Heavy Metals ($\times 10^{-3}$)	Total Chlorinated Organics ($\times 10^{-6}$)	Dyestuff ($\times 10^{-3}$)	Total Hazardous Constituents ($\times 10^{-3}$)
IV	Alabama	0.34	49	1.7	22	17	18.7
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	0.13	18	0.64	8.3	6.4	7.04
VIII	Colorado						
I	Connecticut	0.056	8.2	0.29	3.6	2.9	3.19
III	Delaware						
IV	Florida	0.11	16	0.53	6.9	5.3	5.83
IV	Georgia	0.38	58	1.9	24	19	20.9
IX	Hawaii						
X	Idaho	0.011	1.6	0.053	0.69	0.53	0.583
V	Illinois	0.044	6.5	0.22	2.9	2.2	2.42
V	Indiana						
VII	Iowa	0.022	3.2	0.11	1.5	1.1	1.21
VII	Kansas						
IV	Kentucky	0.067	9.8	0.34	4.3	3.4	3.74
VI	Louisiana	0.034	4.9	0.17	2.2	1.7	1.87
I	Maine	0.011	1.6	0.053	0.69	0.53	0.583
III	Maryland	0.011	1.6	0.053	0.69	0.53	0.583
I	Massachusetts	0.17	24	0.85	11	8.5	9.35
V	Michigan	0.011	1.6	0.053	0.69	0.53	0.583
V	Minnesota	0.056	8.2	0.29	3.6	2.9	3.19
IV	Mississippi	0.044	6.5	0.22	2.9	2.2	2.42
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	0.056	8.2	0.29	3.6	2.9	2.42
II	New Jersey	0.44	65	2.2	29	22	24.2
VI	New Mexico						
II	New York	0.78	120	3.9	51	39	42.9
IV	North Carolina	3.5	510	17	220	170	187.22
VIII	North Dakota						
V	Ohio	0.044	6.5	0.22	2.9	2.2	2.42
VI	Oklahoma	0.011	1.6	0.053	0.69	0.53	0.583
X	Oregon	0.011	1.6	0.053	0.69	0.53	0.583
III	Pennsylvania	0.73	110	3.7	48	37	40.7
I	Rhode Island	0.10	15	0.51	6.5	5.1	5.61
IV	South Carolina	0.67	98	3.4	43	34	37.4
VIII	South Dakota						
IV	Tennessee	0.42	62	2.1	28	21	23.1
VI	Texas	0.044	6.5	0.22	2.9	2.2	2.42
VIII	Utah						
I	Vermont	0.011	1.6	0.053	0.69	0.53	0.583
III	Virginia	0.23	34	1.2	15	12	13.2
X	Washington						
III	West Virginia	0.011	1.6	0.053	0.69	0.53	0.583
V	Wisconsin	0.067	9.8	0.34	4.3	3.4	3.74
VIII	Wyoming						
TOTAL		8.622	1270.1	42.764	552.92	427.64	470.404
Region I		0.404	58.6	2.046	26.08	20.46	22.506
II		1.22	185	6.1	80	61	67.1
III		0.982	147.2	5.006	64.38	50.06	55.066
IV		5.531	809.3	27.19	351.1	271.9	299.09
V		0.222	32.6	1.123	14.39	11.23	12.353
VI		0.089	13	0.443	5.79	4.43	4.873
VII		0.022	3.2	0.11	1.5	1.1	1.21
VIII							
IX		0.13	18	0.64	8.3	6.4	7.04
X		0.022	3.2	0.106	1.38	1.06	1.166

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-27. Category E – Quantities of Potentially Hazardous Wastewater Treatment Sludges from Knit Fabric Dyeing and Finishing Operations,* 1983 (KKG/YR)

		Total Potentially Hazardous Waste		Total Heavy Metals	Total Chlorinated Organics ($\times 10^{-3}$)	Dyestuff	Total Hazardous Constituents
		Dry	Wet ($\times 10^3$)				
IV	Alabama	1,400	5.6	7.2	92	70	77.3
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	520	2.08	2.6	34	26	28.6
VIII	Colorado						
I	Connecticut	220	0.88	1.1	14	11	12.1
III	Delaware						
IV	Florida	490	1.96	2.4	32	24	26.4
IV	Georgia	1,800	7.2	8.8	110	90	98.9
IX	Hawaii						
X	Idaho	37	0.148	0.20	2.4	1.8	2.0
V	Illinois	190	0.76	0.95	12	9.5	10.46
V	Indiana						
VII	Iowa	110	0.44	0.56	7.1	5.5	6.07
VII	Kansas						
IV	Kentucky	300	1.2	1.5	19	15	16.5
VI	Louisiana	150	0.6	0.75	9.7	7.5	8.26
I	Maine	37	0.148	0.20	2.4	1.8	2.0
III	Maryland	37	0.148	0.20	2.4	1.8	2.0
I	Massachusetts	720	2.88	3.6	46	36	39.6
V	Michigan	37	0.148	0.20	2.4	1.8	2.0
V	Minnesota	220	0.88	1.1	14	11	12.1
IV	Mississippi	190	270.76	0.95	12	9.5	10.46
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	220	0.88	1.1	14	11	12.1
II	New Jersey	1,900	7.6	9.5	120	95	104.6
VI	New Mexico						
II	New York		12.8	16	210	160	176
IV	North Carolina	15,000	60	75	970	750	826
VIII	North Dakota						
V	Ohio	190	0.76	0.95	12	9.5	10.46
VI	Oklahoma	37	0.148	0.20	2.4	1.8	2.0
X	Oregon	37	0.148	0.20	2.4	1.8	2.0
III	Pennsylvania	3,100	12.4	15	200	160	175
I	Rhode Island	410	1.64	2.1	26	20	22.1
IV	South Carolina	2,900	11.6	14	180	140	154.2
VIII	South Dakota						
IV	Tennessee	1,800	7.2	9.1	120	90	99.2
VI	Texas	190	0.76	0.95	12	9.5	10.46
VIII	Utah						
I	Vermont	37	0.148	0.20	2.4	1.8	2.0
III	Virginia	980	3.92	4.9	63	49	54.0
X	Washington						
III	West Virginia	37	0.148	0.20	2.4	1.8	2.0
V	Wisconsin	300	1.2	1.5	19	15	16.5
VIII	Wyoming						
TOTAL		36,796	147.184	183.21	2367	1,838.4	2,023.37
Region	I	1,644	6576	8.3	104.8	81.6	89.9
	II	5,100	20.4	25.5	330	255	280.6
	III	4,154	16.616	20.3	267.6	212.6	233.0
	IV	23,880	95.52	118.95	1,535	1,188.5	1,308.96
	V	937	3.748	4.7	59.4	46.8	51.52
	VI	377	1.508	1.9	24.1	18.8	20.72
	VII	110	0.440	0.56	7.1	5.5	6.07
	VIII						
	IX	520	2.08	2.6	34	26	28.6
	X	74	0.296	0.40	4.8	3.6	4.0

*It was not possible to differentiate between the retained and wasted sludge for 1983, so the estimated values for this year reflect the total quantity.

3.4.6.1 Process Descriptions

A mass balanced flow diagram of the typical tufted carpet dyeing and finishing process appears in Figure 3-6. The individual operations are addressed below.

Tufting. Yarn is tufted through the primary backing, usually polypropylene, by the many needles of the tufting machine.

Dye. Carpet which has not been tufted with pre-dyed yarn may be piece dyed or dyed in a kuster dye range (TAK dyed) before the secondary backing is applied. Slightly more dye - an estimated 3 per cent of the weight of the yarn as opposed to the usual 2 per cent - may be used in dyeing due to the generally deeper dyeing of carpets. Anti-soil and anti-static agents may be applied after the carpet is dyed and before finishing.

Finish. Latex and a secondary backing such as jute are applied in a continuous operation to lock the tufted yarns into the primary backing. A rubber foam backing may be applied as an alternative to the jute secondary backing.

Print. Mitter-Stalwart, or Zimmer printing machines are used in this operation. Mostly foam backed carpet is printed, however, shags and plushes may also be printed.

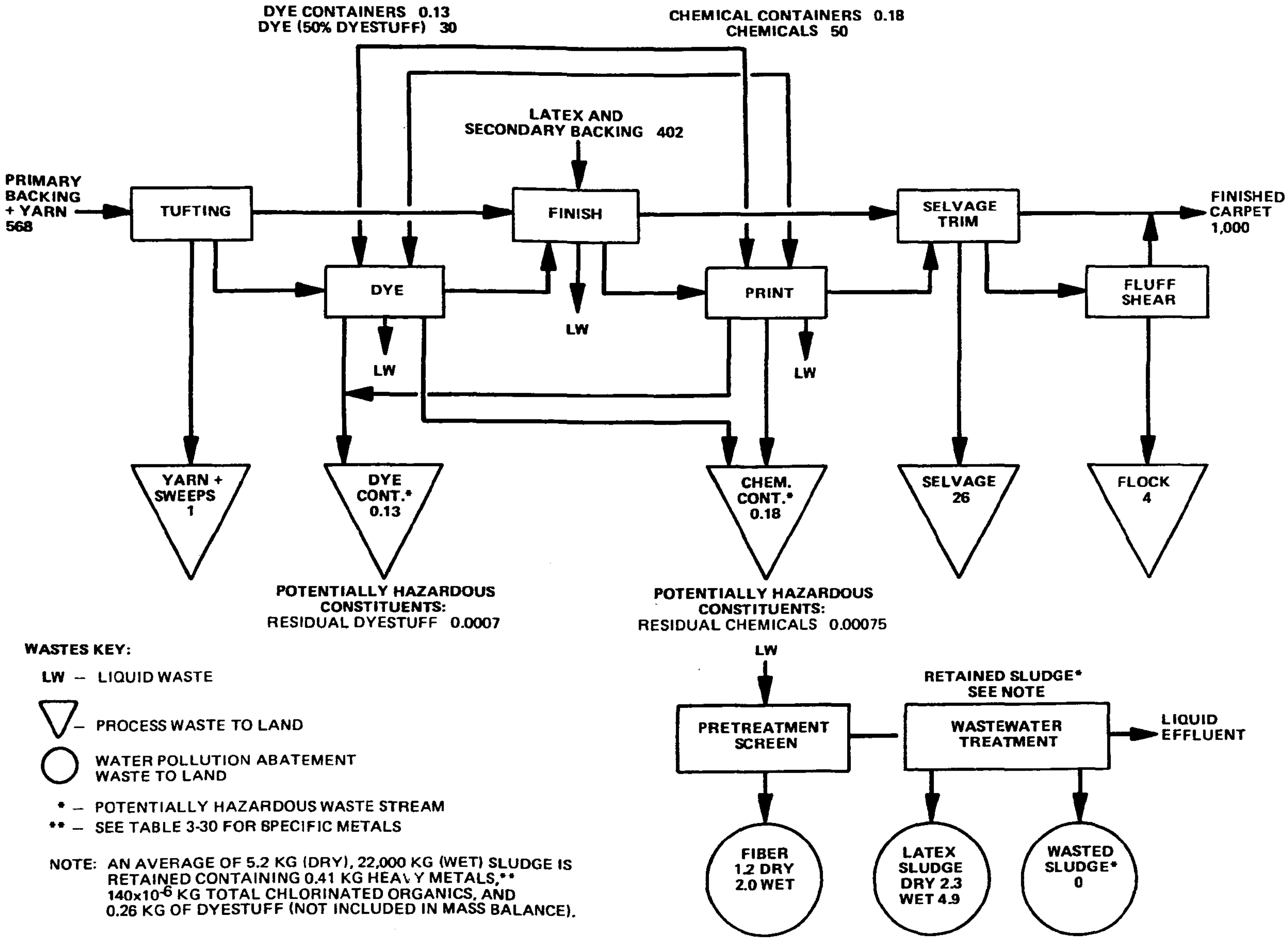
Selvage Trim. Approximately 5 centimeters or 2 inches of selvage is trimmed from each edge of the carpet to assure uniformity of width.

Fluff and Shear. The carpet is beaten to fluff the yarns into an upright position. The carpet is then sheared to give it a uniform surface.

3.4.6.2 Waste Stream Descriptions

In this category the typical plant land-destined waste streams are:

Figure 3-6. CATEGORY F - TYPICAL TUFTED CARPET DYEING AND FINISHING PROCESS



Waste	Source	Quantity (kg of waste/ kkg of product)
yarn and sweeps	tufting	1.0
selvage	selvage trim	26
flock	fluff and shear	4
dye containers	dyeing and printing	0.13
chemical containers	dyeing and printing	0.18
fiber	wastewater pretreatment screen	1.2 (dry) 2.0 (wet)
latex sludge	wastewater treatment	2.3 (dry) 4.9 (wet)
wasted sludge	wastewater treatment	typically none
retained sludge*	wastewater treatment	5.2 kg (dry) 22,000 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

3.4.6.2.1 Potentially Hazardous or Non-Hazardous Constituents *

The yarn, sweeps, selvage, flock, fiber and latex sludge wastes identified in Figure 3-6 are considered non-hazardous. The dye and chemical container waste streams are considered potentially hazardous because they contain hazardous residual dyestuff and chemicals. The potentially hazardous portions of the dye container and chemical container waste streams were determined to be 0.007 kg/kkg of product and 0.00075 kg/kkg of product, respectively.

Sludges retained in the wastewater treatment system also contain hazardous constituents such as heavy metals (zinc), chlorinated organics and dyestuff, and therefore, are also considered potentially hazardous. This industry category does not ordinarily waste sludge.

3.4.6.2.2 Sampling Results

Table 3-28 lists the results of laboratory analyses performed on composite sludge samples taken weekly over a period of four weeks from two plants. In every instance where drinking water limits are established, metals or organics concentrations exceed these limits. Iron accounted for 64 per cent by weight of the total heavy metals content. Analysis performed for total chlorinated organics showed 99.6 per cent by weight of the total content (26.2 ppm) was in the solid phase of the sludge, with the remainder in the liquid phase. The average solid phase concentrations of total chlorinated organics and heavy metals exceeded the drinking water limits at both plants. The liquid phase concentrations of chlorinated organics were all below drinking water standards. Detailed sampling results may be found in Appendix C.

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Table 3-28

Category F - Tufted
Carpet Dyeing & Finishing
Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Range (1)	Average (2)
Arsenic	0.05	<7-<12	<10
Barium	1.0	<70-<120	<95
Cadmium	0.01	<7-<12	<10
Chromium	0.05	100-123	112
Cobalt	**	<36-212	124
Copper	1.0	22-400	211
Iron	0.3	660-9,750	5,200
Lead	0.05	<70-150	110
Manganese	0.05	101-412	256
Molybdenum	**	<145-<250	<198
Nickel	**	<36-<62	<49
Zinc	5.0	254-3,325	1,790
Total Heavy Metals			8,117
Aluminum	**	1,740-7,120	4,430
Magnesium	60.0	1,580-2,060	1,820
Potassium	**	1,490-6,540	4,020
Sodium	**	41,000-91,250	66,100
Strontium	**	29-<38	33
Total Chlorinated Organics	0.7	1.03-51.4	26.2
Suspended Solids (%)	**	0.016-0.03	0.024
Total Solids (%)	**	0.08-0.14	0.11

(1) Range of the individual plant averages
(2) Grand average of 12 measurements from three plants
(3) Less than values were considered to be at the maximum in computing totals
* U.S. Public Health Service. Drinking Water Standards. 1962
** No drinking water standards have been set for these metals

An average of 5.2 kg (dry) or 22,000 kg (wet) of sludge is retained in the typical direct discharge plant's wastewater treatment system, containing 0.41 kg of total heavy metals, 1.4×10^{-4} kg of total chlorinated organics, and 0.26 kg of dyestuff.

3.4.6.3 Waste Quantities for 1974, 1977 and 1983

Waste generation rates (kg of waste/metric ton of product) identified in Figure 3-6 were applied to production rates to give wastes quantities. Increases in production of 12.5 per cent in 1976 and 10.5 per cent in 1977, projected by the Carpet and Rug Institute (1) were applied to all current year waste quantities to give 1977 amounts. The contractor estimated that an average annual increase of 12 per cent would be maintained until 1980, at which point a downturn to 9 per cent would take effect, due to the continuing demand for smaller housing units and the impact of declining birth rates affecting the total number of households in the 1980's. This rationale was followed in projecting 1983 container and innocuous wastes.

Table 3-29 quantifies the total wastes for this category in 1974, 1977 and 1983. Tables 3-30, 3-31, and 3-32 list dye and chemical container and potentially hazardous container residual wastes for 1974, 1977 and 1983, respectively.

Sludge quantities and its potentially hazardous constituents amounts appear in Tables 3-33, 3-34 and 3-35 for 1974, 1977 and 1983, respectively. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered valid to relate sludge quantities to production. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

3.4.7 Category G - Yarn and Stock Dyeing and Finishing

The eleven plants visited in this category are located in Alabama, Connecticut, Georgia, North Carolina, South Carolina and Tennessee. Two of the plants are integrated, beginning with stock and ending with woven fabric, while three others begin with stock and end with yarn. The remaining six plants begin with greige yarn and end with bleached or dyed, finished yarn. The number of employees at these plants range from 120 to 1,500 and average 620. Plants usually operate 3 shifts per day, 5 to 6 days per week, 50 weeks per year. Excluding the two integrated mills, annual yarn production ranges from 540 to 13,000 metric tons.

Table 3-29. Category F - Estimated Quantities of Total Waste from Tufted Carpet Dyeing and Finishing Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama	313	356	394	450	912	1,570
X	Alaska						
IX	Arizona						
VI	Arkansas	313	356	394	450	912	1,570
IX	California	2,824	3,234	3,531	4,071	8,155	13,955
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	141	157	182	199	404	667
IV	Georgia	14,127	16,707	18,159	21,428	40,790	70,290
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	141	157	182	199	404	667
VII	Iowa						
VII	Kansas						
IV	Kentucky	313	356	394	450	912	1,570
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	313	356	394	450	912	1,570
V	Michigan	141	157	182	199	404	667
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	141	157	182	199	404	667
VI	New Mexico						
II	New York	454	512	565	637	1,289	2,229
IV	North Carolina	938	1,046	1,211	1,359	2,679	4,559
VIII	North Dakota						
V	Ohio	141	157	182	199	404	667
VI	Oklahoma	313	356	394	450	912	1,570
X	Oregon						
III	Pennsylvania	767	868	959	1,048	2,614	3,708
I	Rhode Island						
IV	South Carolina	938	1,046	1,211	1,359	2,679	4,559
VIII	South Dakota						
IV	Tennessee	626	711	787	888	1,793	3,133
VI	Texas	313	356	394	450	912	1,570
VIII	Utah	141	157	182	199	404	667
I	Vermont						
III	Virginia	141	157	182	199	404	667
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		23,539	27,359	30,061	34,344	67,849	116,522
Region I		313	356	394	450	912	1,570
II		595	669	747	836	1,693	2,896
III		908	1,025	1,141	1,247	2,568	4,375
IV		17,396	20,379	22,338	25,594	50,169	86,348
V		423	471	548	597	1,212	2,001
VI		939	1,068	1,182	1,350	2,736	4,710
VII							
VIII		141	159	182	199	404	667
IX		2,824	3,234	3,531	4,071	8,155	13,955
X							

Table 3-30. Category F – Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Tufted Carpet Dyeing and Finishing Operations, 1974 (KKG/YR) Dry Weight*

Region	State	Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	1.2	0.006	1.6	0.007	2.813	0.013
X	Alaska						
IX	Arizona						
VI	Arkansas	1.2	0.006	1.6	0.007	2.813	0.013
IX	California	10	0.057	14	0.061	24.118	0.118
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	0.52	0.003	0.72	0.003	1.246	0.006
IV	Georgia	53	0.29	74	0.31	127.6	0.6
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	0.52	0.003	0.72	0.003	1.246	0.006
VII	Iowa						
VII	Kansas						
IV	Kentucky	1.2	0.006	1.6	0.007	2.813	0.013
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	1.2	0.006	1.6	0.007	2.813	0.013
V	Michigan	0.52	0.003	0.72	0.003	1.246	0.006
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	0.52	0.003	0.72	0.003	1.246	0.006
VI	New Mexico						
II	New York	1.7	0.009	2.3	0.010	4.019	0.019
IV	North Carolina	3.5	0.019	4.9	0.020	8.439	0.039
VIII	North Dakota						
V	Ohio	0.52	0.003	0.72	0.003	1.246	0.006
VI	Oklahoma	1.2	0.006	1.6	0.007	2.813	0.013
X	Oregon						
III	Pennsylvania	2.9	0.015	4	0.016	6.931	0.031
I	Rhode Island						
IV	South Carolina	3.5	0.019	4.9	0.020	8.439	0.039
VIII	South Dakota						
IV	Tennessee	2.3	0.013	3.2	0.014	5.527	0.027
VI	Texas	1.2	0.006	1.6	0.007	2.813	0.013
VIII	Utah	0.52	0.003	0.72	0.003	1.246	0.006
I	Vermont						
III	Virginia	0.52	0.003	0.72	0.003	1.246	0.006
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		87.74	0.479	121.94	0.514	210.673	0.993
Region I		1.2	0.006	1.6	0.007	2.813	0.013
II		2.22	0.012	3.02	0.013	5.265	0.025
III		3.42	0.018	4.72	0.019	8.177	0.037
IV		65.22	0.356	90.92	0.381	156.877	0.737
V		1.56	0.009	2.16	0.009	3.738	0.018
VI		3.6	0.018	4.8	0.021	8.439	0.039
VII							
VIII		0.52	0.003	0.72	0.003	1.246	0.006
IX		10	0.057	14	0.061	24.118	0.118
X							

* Dry Weight = Wet Weight

Table 3-31. Category F - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Tufted Carpet Dyeing and Finishing Operations, 1977 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	1.5	0.0075	2.0	0.0088	3.5163	0.0163
X	Alaska						
IX	Arizona						
VI	Arkansas	1.5	0.0075	2.0	0.0088	3.5163	0.0163
IX	California	13	0.072	18	0.077	31.149	0.149
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	0.65	0.0038	0.90	0.0038	1.5576	0.0076
IV	Georgia	66	0.36	93	0.39	159.75	0.75
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	0.65	0.0038	0.90	0.0038	1.5576	0.0076
VII	Iowa						
VII	Kansas						
IV	Kentucky	1.5	0.0075	2.0	0.0088	3.5163	0.0163
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	1.5	0.0075	2.0	0.0088	3.5163	0.0163
V	Michigan	0.65	0.0038	0.90	0.0038	1.5576	0.0076
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	0.65	0.0038	0.90	0.0038	1.5576	0.0076
VI	New Mexico						
II	New York	2.1	0.011	2.9	0.013	5.024	0.024
IV	North Carolina	4.4	0.024	6.1	0.025	10.549	0.049
VIII	North Dakota						
V	Ohio	0.65	0.0038	0.90	0.0038	1.5576	0.0076
VI	Oklahoma	1.5	0.0075	2.0	0.0088	3.5163	0.0163
X	Oregon						
III	Pennsylvania	3.6	0.019	5.0	0.020	8.639	0.039
I	Rhode Island						
IV	South Carolina	4.4	0.024	6.1	0.025	10.549	0.049
VIII	South Dakota						
IV	Tennessee	2.9	0.016	4.0	0.018	6.934	0.034
VI	Texas	1.5	0.0075	2.0	0.0088	3.5163	0.0163
VIII	Utah	0.65	0.0038	0.90	0.0038	1.5576	0.0076
I	Vermont						
III	Virginia	0.65	0.0038	0.90	0.0038	1.5576	0.0076
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		109.95	0.5976	153.4	0.6474	264.595	1.245
Region I		1.5	0.0075	2.0	0.0088	3.5163	0.0163
II		2.75	0.0148	3.8	0.0168	6.5816	0.0316
III		4.25	0.0228	5.9	0.0238	10.1966	0.0466
IV		81.35	0.4428	114.1	0.4794	196.3722	0.9222
V		1.95	0.0114	2.7	0.0114	4.6728	0.0228
VI		4.5	0.0225	6.0	0.0264	10.5489	0.0489
VII							
VIII		0.65	0.0038	0.90	0.0038	1.5576	0.0076
IX		13	0.072	18	0.077	31.149	0.149
X							

* Dry Weight = Wet Weight

Table 3-32. Category F - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Tufted Carpet Dyeing and Finishing Operations, 1983 (KKG/YR) Dry Weight*

Region	State	Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	2.7	0.014	3.6	0.016	6.33	0.030
X	Alaska						
IX	Arizona						
VI	Arkansas	2.7	0.014	3.6	0.016	6.33	0.030
IX	California	23	0.13	32	0.14	55.27	0.27
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	1.2	0.0068	1.6	0.0068	2.8136	0.0136
IV	Georgia	120	0.66	170	0.71	291.37	1.37
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	1.2	0.0068	1.6	0.0068	2.8136	0.0136
VII	Iowa						
VII	Kansas						
IV	Kentucky	2.7	0.014	3.6	0.016	6.33	0.030
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	2.7	0.014	3.6	0.016	6.33	0.030
V	Michigan	1.2	0.0068	1.6	0.0068	2.8136	0.0136
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	1.2	0.0068	1.6	0.0068	2.8136	0.0136
VI	New Mexico						
II	New York	3.9	0.021	5.2	0.023	9.144	0.044
IV	North Carolina	8.0	0.043	11	0.046	19.089	0.089
VIII	North Dakota						
V	Ohio	1.2	0.0068	1.6	0.0068	2.8136	0.0136
VI	Oklahoma	2.7	0.014	3.6	0.016	6.33	0.030
X	Oregon						
III	Pennsylvania	6.6	0.034	9.1	0.036	15.77§	0.070
I	Rhode Island						
IV	South Carolina	8.0	0.043	11	0.046	19.089	0.089
VIII	South Dakota						
IV	Tennessee	5.2	0.030	7.3	0.032	12.562	0.062
VI	Texas	2.7	0.014	3.6	0.016	6.33	0.030
VIII	Utah	1.2	0.0068	1.6	0.0068	2.8136	0.0136
I	Vermont						
III	Virginia	1.2	0.0068	1.6	0.0068	2.8136	0.0136
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		199.3	1.0926	278.4	1.1766	479.9692	2.2692
Region I		2.7	0.014	3.6	0.016	6.33	0.030
II		5.1	0.0278	6.8	0.0298	11.9576	0.0576
III		7.8	0.0408	10.7	0.0428	18.5836	0.0836
IV		147.8	0.8108	208.1	0.8728	357.5836	1.6836
V		3.6	0.0204	4.8	0.0204	8.4408	0.0408
VI		8.1	0.042	10.8	0.048	18.99	0.090
VII							
VIII		1.2	0.0068	1.6	0.0068	2.8136	0.0136
IX		23	0.13	32	0.14	55.27	0.27
X							

* Dry Weight = Wet Weight

Table 3-33. Category F - Tufted Carpet Dyeing and Finishing Wastewater Treatment Sludges, 1974

		RETAINED SLUDGES (KKG) * (NO WASTED SLUDGES)					
		Total Dry (x 10-3)	Total Wet	Total Heavy Metals (x 10-6)	Total Chlor-inated Organics (x 10-9)	Dyestuff (x 10-3)	Total Hazardous Constituents (x 10-6)
IV	Alabama	3.0	13	24	79	0.15	174
X	Alaska						
IX	Arizona						
VI	Arkansas	3.0	13	24	79	0.15	174
IX	California	27	110	210	710	1.4	1610
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	1.4	5.6	11	37	0.07	81
IV	Georgia	138	580	1100	3600	6.9	8000
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	1.4	5.6	11	37	0.07	81
VII	Iowa						
VII	Kansas						
IV	Kentucky	3.0	13	24	79	0.15	174
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	3.0	13	24	79	0.15	174
V	Michigan	1.4	5.6	11	37	0.07	81
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	1.4	5.6	11	37	0.07	81
VI	New Mexico						
II	New York	4.4	18	35	120	0.22	255
IV	North Carolina	9.1	38	72	240	0.46	532
VIII	North Dakota						
V	Ohio	1.4	5.6	11	37	0.07	81
VI	Oklahoma	3.0	13	24	79	0.15	174
X	Oregon						
III	Pennsylvania	7.4	31	59	190	0.37	429
I	Rhode Island						
IV	South Carolina	9.1	38	72	240	0.46	532
VIII	South Dakota						
IV	Tennessee	6.1	25	48	160	0.30	348
VI	Texas	3.0	13	24	79	0.15	174
VIII	Utah	1.4	5.6	11	37	0.07	81
I	Vermont						
III	Virginia	1.4	5.6	11	37	0.07	81
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		228.9	957.2	1817	5993	11.5	13,317
Region I		3.0	13	24	79	0.15	174
II		5.8	23.6	46	157	0.29	336
III		8.8	36.6	70	227	0.44	510
IV		169.7	712.6	1351	4435	8.49	9841
V		4.2	16.8	33	111	0.21	243
VI		9.0	39	72	237	0.45	522
VII							
VIII		1.4	5.6	11	37	0.07	81
IX		27	110	210	710	1.4	1610
X							

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-34. Category F - Tufted Carpet Dyeing and Finishing Wastewater Treatment Sludges, 1977

Region	State	RETAINED SLUDGES (KKG)* (NO WASTED SLUDGES) Total Dry (x 10^{-3})	Total Wet	Total Heavy Metals (x 10^{-6})	Total Chlorinated Organics (x 10^{-9})	Dyestuff (x 10^{-3})	Total Hazardous Constituents (x 10^{-6})
IV	Alabama	3.8	16	30	99	0.19	220
X	Alaska						
IX	Arizona						
VI	Arkansas	3.8	16	30	99	0.19	220
IX	California	34	140	260	890	1.8	2060
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	1.8	7.0	14	46	0.088	102
IV	Georgia	170	730	1400	4500	8.6	10,000
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	1.8	7.0	14	46	0.088	102
VII	Iowa						
VII	Kansas						
IV	Kentucky	3.8	16	30	99	0.19	220
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	3.8	16	30	99	0.19	220
V	Michigan	1.8	7.0	14	46	0.088	102
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	1.8	7.0	14	46	0.088	102
VI	New Mexico						
II	New York	5.5	22	44	150	0.28	324
IV	North Carolina	11	48	90	300	0.58	670
VIII	North Dakota						
V	Ohio	1.8	7.0	14	46	0.088	102
VI	Oklahoma	3.8	16	30	99	0.19	220
X	Oregon						
III	Pennsylvania	9.3	39	74	240	0.46	534
I	Rhode Island						
IV	South Carolina	11	48	90	300	0.58	670
VIII	South Dakota						
IV	Tennessee	7.6	31	60	200	0.38	440
VI	Texas	3.8	16	30	99	0.19	220
VIII	Utah	1.8	7.0	14	46	0.088	102
I	Vermont						
III	Virginia	1.8	7.0	14	46	0.088	102
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		283.8	1203	2296	7496	14.436	16732
Region I		3.8	16	30	99	0.19	220
II		7.3	29	58	196	0.368	426
III		11.1	46	88	286	0.548	636
IV		209	896	1714	5544	10.608	12,322
V		5.4	21	42	138	0.264	306
VI		11.4	48	90	297	0.57	660
VII							
VIII		1.8	7	14	46	0.088	102
IX		34	140	260	890	1.8	2060
X							

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-35. Category F – Quantities of Potentially Hazardous Wastewater Treatment Sludges From Tufted Carpet Dyeing and Finishing Operations,* 1983 (KKG/YR)

		Total Potential Hazardous Wastes		Total Heavy Metals	Total Chlorinated Organics (x 10^{-3})	Dyestuff	Total Hazardous Constituents
		Dry	Wet (x 10^3)				
IV	Alabama	196	0.784	1.6	5.1	9.8	11.4
X	Alaska						
IX	Arizona						
VI	Arkansas	196	0.784	1.6	5.1	9.8	11.4
IX	California		6.8	13	44	85	98
VIII	Colorado						
I	Connecticut						
III	Delaware						
IV	Florida	81	0.324	0.64	2.1	4.0	4.64
IV	Georgia		34	67	220	420	487
IX	Hawaii						
X	Idaho						
V	Illinois						
V	Indiana	81	0.324	0.64	2.1	4.0	4.64
VII	Iowa						
VII	Kansas						
IV	Kentucky	196	0.784	1.6	5.1	9.8	11.4
VI	Louisiana						
I	Maine						
III	Maryland						
I	Massachusetts	196	0.784	1.6	5.1	9.8	11.4
V	Michigan	81	0.324	0.64	2.1	4.0	4.64
V	Minnesota						
IV	Mississippi						
VII	Missouri						
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire						
II	New Jersey	81	0.324	0.64	2.1	4.0	4.64
VI	New Mexico						
II	New York	280	1.12	2.2	7.3	14	16.2
IV	North Carolina	560	2.24	4.4	15	28	32.4
VIII	North Dakota						
V	Ohio	81	0.324	0.64	2.1	4.0	4.46
VI	Oklahoma	196	0.784	1.6	5.1	9.8	11.4
X	Oregon						
III	Pennsylvania	448	1.792	3.5	12	22	25.5
I	Rhode Island						
IV	South Carolina	560	2.24	4.4	15	28	32.4
VIII	South Dakota						
IV	Tennessee	380	1.52	3.0	10	19	22
VI	Texas	196	0.784	1.6	5.1	9.8	11.4
VIII	Utah	81	0.324	0.64	2.1	4.0	4.64
I	Vermont						
III	Virginia	81	0.324	0.64	2.1	4.0	4.64
X	Washington						
III	West Virginia						
V	Wisconsin						
VIII	Wyoming						
TOTAL		14,171	56.684	111.58	368.6	702.8	814.38
Region I		196	0.784	1.6	5.1	9.8	11.4
II		361	1.444	2.84	9.4	18	20.84
III		529	2.116	4.14	14.1	26	30.1
IV		10,473	41.892	82.64	272.3	518.6	601.24
V		243	0.972	1.92	6.3	12	13.9
VI		588	2.352	4.8	15.3	29.4	34.2
VII							
VIII		81	0.324	0.64	2.1	4.0	4.64
IX		1,700	6.8	13	44	85	98
X							

*It was not possible to differentiate between the retained and wasted sludge for 1983, so the estimated values for this year reflect the total quantity.

3.4.7.1 Process Description

A mass balanced flow diagram of the typical yarn and stock dyeing and finishing process is shown in Figure 3-7. The individual operations are addressed below.

Mercerize. This operation is performed on cotton yarn by only a few plants. The yarn is treated by a caustic bath to swell the cotton fiber. This imparts increased dye affinity, greater tensile strength, and luster to the yarn.

Bleach. If the yarn is to remain white or to be dyed a very light shade, it may be bleached to remove its natural yellowish color.

Dye. Stock is dyed in becks, as is yarn. Yarn is usually package dyed, skein dyed, or beam dyed.

Dry. The dyed stock, which has matted into a cake in the dyeing operation, is broken up and oven dried. After drying, it may be blown into a bin and await yarn preparation (as discussed in Section 3.4.3.1, Greige Goods Process Description) or it may be baled and sold or stored. Yarn may be oven dried or dried in the beck in which it was dyed.

Finish or Slash. Yarn may be finished with a lubricant prior to knitting or sewing, or beamed and then slashed with compounds such as carboxymethyl cellulose (CMC), polyvinyl alcohol (PVA), and starch prior to weaving, or may bypass this step entirely.

Beam, Quill, Wind, etc. These operations are mechanical handling operations intended to ready the yarn for the loom or knitting machine.

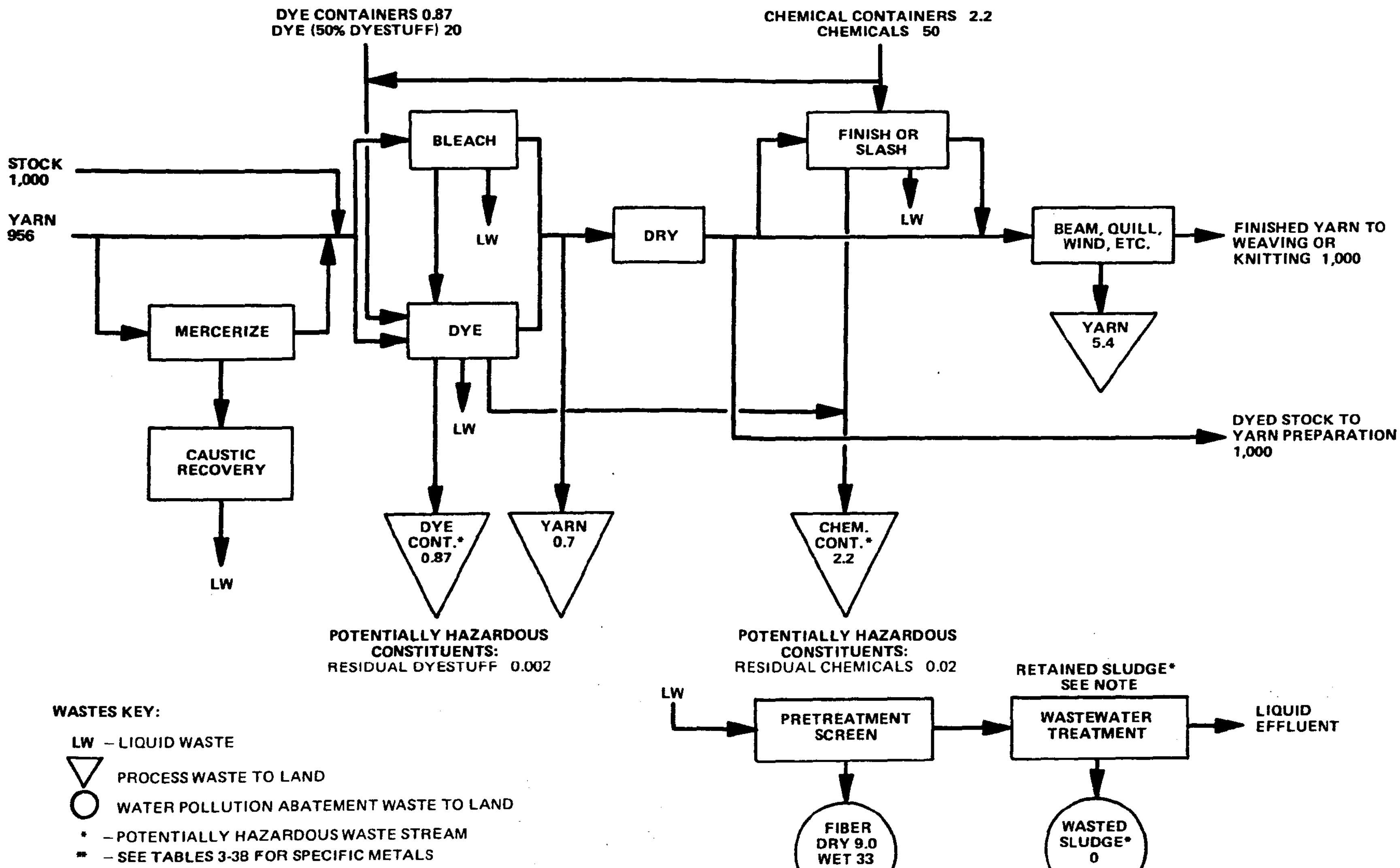
3.4.7.2 Waste Stream Description

The land-destined waste streams from a typical plant in this category are:

Waste	Source	Quantity, (kg of waste/ kkg of product)
yarn	bleaching/dyeing	0.7
yarn	beaming/quilling/ winding, etc.	5.4
dye containers	dyeing	0.87
chemical containers	dyeing and finishing	2.2
fiber	wastewater pretreatment screen	9.0 (dry) 33 (wet)
wasted sludge	wastewater treatment	typically none
retained sludge*	wastewater treatment	2.9 kg (dry) 20,000 kg (wet)

* The retained sludge quantity is an accumulation over the life of the pond.

Figure 3-7. CATEGORY G - TYPICAL YARN AND STOCK DYEING AND FINISHING PROCESS



NOTE: AN AVERAGE OF 2.9 KG (DRY), 20,000 KG (WET) SLUDGE IS RETAINED CONTAINING 0.01 KG HEAVY METALS,** 120×10^{-6} KG TOTAL CHLORINATED ORGANICS, AND 0.14 KG OF DYESTUFF (NOT INCLUDED IN MASS BALANCE).

3.4.7.2.1 Potentially Hazardous or Non-Hazardous Constituents *

The fiber and yarn wastes identified in Figure 3-7 are considered non-hazardous. The dye and chemical container waste streams are considered potentially hazardous because they contain hazardous residual dyestuff and chemicals. The potentially hazardous portions of the dye container and chemical container waste streams were determined to be 0.002 kg/kkg of product and 0.02 kg/kkg of product, respectively.

Sludges retained in the wastewater treatment system (typically, no sludges are currently disposed) also contain hazardous constituents such as heavy metals (copper, zinc), chlorinated organics and dyestuff, and therefore, are also considered potentially hazardous.

3.4.7.2.2 Sampling Results

Table 3-36 lists the results of the analyses performed on composite sludge samples taken weekly over a period of four weeks from two plants. In every instance the average metals or chlorinated organics concentrations in the sludge solids exceeded the drinking water quality limits. Iron and zinc together accounted for 87 per cent by weight of the total heavy metals content of the sludge. Analysis performed for total chlorinated organics showed 99.9 per cent by weight of the total content (40.1 ppm) was found in the solid phase of the sludge. The remaining 0.1 per cent (0.03 ppm) of chlorinated organics found in the liquid phase does not exceed drinking water standards for total organics. Detailed sampling results may be found in Appendix C of this report.

An average of 2.9 kg (dry) or 20,000 kg (wet) of sludge is retained in the typical plant's wastewater treatment system, containing 0.01 kg of total heavy metals, 1.2×10^{-4} kg of total chlorinated organics, and 0.14 kg of dyestuff.

3.4.7.3 Waste Quantities for 1974, 1977 and 1983

Because much of this category's products are processed by Categories D and E and are ultimately used for apparel, furnishings and other consumer products, waste projections are closely related to population growth. (A growth factor of 3 per cent per annum was estimated by the contractor). Table 3-37 quantifies the total wastes for this category for 1974, 1977 and 1983.

Tables 3-38, 3-39 and 3-40 list dye and chemical container and potentially hazardous container residuals wastes for 1974, 1977 and 1983, respectively.

Sludge quantities and its potentially hazardous constituents amounts appear in Tables 3-41, 3-42 and 3-43 for 1974, 1977 and 1983, respectively. Because there is little or no change anticipated in textile wastewater treatment in 1977, it was considered valid to relate sludge

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Table 3-36

Category G - Yarn & Stock
Dyeing & Finishing
Sludge Analyses
(mg/kg of dry sludge)

Parameter	Drinking Water Limit* (ppm)	Range(1)	Average(2)
Arsenic	0.05	<0.01-<5	<2.5(3)
Barium	1.0	<0.1-<50	<25
Cadmium	0.01	<0.01-<5	<2.5
Chromium	0.05	24.4-38	31
Cobalt	**	<0.05-<24	12
Copper	1.0	105-423	264
Iron	0.3	605-2,715	1,660
Lead	0.05	<0.1-<50	<25
Manganese	0.05	10-122	66
Mercury	0.002	<0.5-0.81	0.66
Molybdenum	**	<0.2-<100	50
Nickel	**	<0.05-<24	12
Zinc	5.0	571-2439	1,505
Total Heavy Metals			3,656
Aluminum	**	357-2,276	1,320
Magnesium	60.0	405-6,772	3,590
Potassium	**	2,100-7,431	4,770
Sodium	**	221,000-497,000	359,000
Strontium	**	14-65	40
Total Chlorinated Organics	0.7	3.3-76.8	40.1
Suspended Solids (%)	**	0.013-0.018	0.015
Total Solids (%)	**	0.12-0.21	0.165

(1) Range of the individual plant averages
(2) Grand average of 8 measurements from two plants
(3) Less than values were considered to be at the maximum in computing totals
* U.S. Public Health Service. Drinking Water Standards. 1962
** No drinking water standards have been set for these metals

Table 3-37. Category G – Estimated Quantities of Total Waste from Yarn and Stock Dyeing and Finishing Operations (KKG/YR)

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama	687	1,646	724	1,755	1,462	4,412
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	687	1,646	724	1,755	1,462	4,412
VIII	Colorado						
I	Connecticut	529	1,211	565	1,318	1,133	3,353
III	Delaware						
IV	Florida						
IV	Georgia	3,600	8,450	3,840	9,000	7,560	22,560
IX	Hawaii						
X	Idaho						
V	Illinois	687	1,646	724	1,755	1,462	4,412
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	181	428	192	450	389	1,169
VI	Louisiana						
I	Maine	181	428	192	450	389	1,169
III	Maryland						
I	Massachusetts	1,679	3,948	1,794	3,967	3,550	10,550
V	Michigan						
V	Minnesota	91	219	98	231	190	566
IV	Mississippi						
VII	Missouri	181	428	192	450	389	1,169
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	434	1,032	458	1,097	934	2,814
II	New Jersey	2,420	5,820	2,550	6,160	5,130	15,630
VI	New Mexico						
II	New York	3,240	7,670	3,470	8,110	6,880	20,780
IV	North Carolina	7,460	17,570	7,930	18,660	15,860	47,560
VIII	North Dakota						
V	Ohio	348	812	372	857	743	2,213
VI	Oklahoma	91	219	98	231	190	566
X	Oregon	91	219	98	231	190	566
III	Pennsylvania	2,770	6,590	2,900	7,030	5,990	18,190
I	Rhode Island	2,160	5,157	2,290	5,486	4,660	14,060
IV	South Carolina	1,566	3,732	1,681	3,957	3,336	10,236
VIII	South Dakota						
IV	Tennessee	687	1,646	724	1,755	1,462	4,412
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	181	428	192	450	389	1,169
X	Washington						
III	West Virginia						
V	Wisconsin	181	428	192	450	389	1,169
VIII	Wyoming						
TOTAL		30,132	71,367	32,000	75,599	64,139	193,137
Region I		4,983	11,770	5,299	12,318	10,666	31,946
II		5,660	13,490	6,020	14,270	12,010	36,410
III		2,951	7,018	3,092	7,480	6,379	19,359
IV		14,181	33,472	15,091	35,571	30,069	90,349
V		1,037	3,105	1,386	3,293	2,784	8,360
VI		91	219	98	231	190	566
VII		181	428	192	450	389	1,169
VIII							
IX		687	1,646	724	1,755	1,462	4,412
X		91	219	98	231	190	566

Table 3-38. Category G - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Yarn and Stock Dyeing and Finishing Operations, 1974 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	33	0.076	84	0.76	117.836	0.836
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	33	0.076	84	0.76	117.836	0.836
VIII	Colorado						
I	Connecticut	25	0.058	64	0.58	89.638	0.638
III	Delaware						
IV	Florida						
IV	Georgia	170	0.390	430	3.9	604.29	0.836
IX	Hawaii						
X	Idaho						
V	Illinois	33	0.076	84	0.76	117.836	0.836
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	8.7	0.020	22	0.20	30.92	0.22
VI	Louisiana						
I	Maine	8.7	0.020	22	0.20	30.92	0.22
III	Maryland						
I	Massachusetts	79	0.18	200	1.8	280.98	1.98
V	Michigan						
V	Minnesota	4.4	0.010	11	0.10	15.51	0.11
IV	Mississippi						
VII	Missouri	8.7	0.020	22	0.20	30.92	0.22
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	21	0.048	53	0.48	74.528	0.528
II	New Jersey	120	0.27	300	2.7	422.97	2.97
VI	New Mexico						
II	New York	150	0.36	390	3.6	543.96	3.96
IV	North Carolina	360	0.82	900	8.2	1,269.02	9.02
VIII	North Dakota						
V	Ohio	16	0.038	42	0.38	58.418	0.418
VI	Oklahoma	4.4	0.010	11	0.10	15.51	0.11
X	Oregon	4.4	0.010	11	0.10	15.51	0.11
III	Pennsylvania	130	0.31	340	3.1	473.41	3.41
I	Rhode Island	100	0.24	260	2.4	362.64	2.64
IV	South Carolina	76	0.17	190	1.7	267.87	1.87
VIII	South Dakota						
IV	Tennessee	33	0.076	84	0.76	117.836	0.836
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	8.7	0.020	22	0.20	30.92	0.22
X	Washington						
III	West Virginia						
V	Wisconsin	8.7	0.020	22	0.20	30.92	0.22
VIII	Wyoming						
TOTAL		1,435.7	3.318	3,648	33.18	5,120.198	36.498
Region I		233.7	0.546	599	5.46	838.706	6.006
II		270	0.63	690	6.3	966.93	6.93
III		138.7	0.33	362	3.3	504.33	3.63
IV		680.7	1.552	1710	15.52	2,407.772	17.072
V		62.1	0.144	159	1.44	222.684	1.584
VI		4.4	0.010	11	0.10	15.51	0.11
VII		8.7	0.020	22	0.20	30.92	0.22
VIII							
IX		33	0.076	84	0.76	117.836	0.836
X		4.4	0.010	11	0.10	15.51	0.11

* Dry Weight = Wet Weight

Table 3-39. Category G - Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Yarn and Stock Dyeing and Finishing Operations, 1977 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals *	Total Potentially Hazardous Wastes	Total Hazardous Constituents
IV	Alabama	35	0.081	89	0.81	124.891	0.891
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	35	0.081	89	0.81	124.891	0.891
VIII	Colorado						
I	Connecticut	27	0.062	68	0.62	95.682	0.682
III	Delaware						
IV	Florida						
IV	Georgia	180	0.41	460	4.1	644.51	4.51
IX	Hawaii						
X	Idaho						
V	Illinois	35	0.081	89	0.81	124.891	0.891
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	9.2	0.021	23	0.21	32.431	0.231
VI	Louisiana						
I	Maine	9.2	0.021	23	0.21	32.431	0.231
III	Maryland						
I	Massachusetts	84	0.19	210	1.9	296.09	2.09
V	Michigan						
V	Minnesota	4.7	0.011	12	0.11	16.821	0.121
IV	Mississippi						
VII	Missouri	9.2	0.021	23	0.21	32.431	0.231
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	22	0.051	56	0.51	78.561	0.561
II	New Jersey	130	0.29	320	2.9	453.19	3.19
VI	New Mexico						
II	New York	160	0.38	410	3.8	574.18	4.18
IV	North Carolina	380	0.87	950	8.7	1,339.57	9.57
VIII	North Dakota						
V	Ohio	17	0.040	45	0.40	62.44	0.44
VI	Oklahoma	4.7	0.011	12	0.11	16.821	0.121
X	Oregon	4.7	0.011	12	0.11	16.821	0.121
III	Pennsylvania	140	0.33	360	3.3	503.63	3.63
I	Rhode Island	110	0.25	280	2.5	392.75	2.75
IV	South Carolina	81	0.18	200	1.8	282.98	1.98
VIII	South Dakota						
IV	Tennessee	35	0.081	89	0.81	124.891	0.891
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	9.2	0.021	23	0.21	32.431	0.231
X	Washington						
III	West Virginia						
V	Wisconsin	9.2	0.021	23	0.21	32.431	0.231
VIII	Wyoming						
TOTAL		1,531.1	3.515	3,866	35.15	5,435.765	38.665
Region I		252.2	0.574	637	5.74	895.514	6.314
II		290	0.67	730	6.7	1,027.37	7.37
III		149.2	0.351	383	3.51	536.061	3.861
IV		720.2	1.643	1811	16.43	2,549.273	18.073
V		65.9	0.153	169	1.53	236.583	1.683
VI		4.7	0.011	12	0.11	16.821	0.121
VII		9.2	0.021	23	0.21	32.431	0.231
VIII							
IX		35	0.081	89	0.81	124.891	0.891
X		4.7	0.011	12	0.11	16.821	0.121

* Dry Weight = Wet Weight

Table 3-40. Category G – Quantities of Potentially Hazardous Dye and Chemical Container Wastes from Yarn and Stock Dyeing and Finishing Operations, 1983 (KKG/YR) Dry Weight*

		Dye Container	Hazardous Residual Dyestuff	Chemical Container	Hazardous Residual Chemicals	Total Potentially Hazardous Waste	Total Hazardous Constituents
IV	Alabama	42	0.096	110	0.96	153.056	1.056
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	42	0.096	110	0.96	153.056	1.056
VIII	Colorado						
I	Connecticut	32	0.073	81	0.73	113.803	0.803
III	Delaware						
IV	Florida						
IV	Georgia	220	0.49	540	4.9	765.39	5.39
IX	Hawaii						
X	Idaho						
V	Illinois	42	0.096	110	0.96	153.056	1.056
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	11	0.025	28	0.25	39.275	0.275
VI	Louisiana						
I	Maine	11	0.025	28	0.25	39.275	0.275
III	Maryland						
I	Massachusetts	100	0.23	250	2.3	352.53	2.53
V	Michigan						
V	Minnesota	5.6	0.013	14	0.13	19.743	0.143
IV	Mississippi						
VII	Missouri	11	0.025	28	0.25	39.275	0.275
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	27	0.061	67	0.61	94.671	0.671
II	New Jersey	150	0.34	380	3.4	533.74	3.74
VI	New Mexico						
II	New York	190	0.46	490	4.6	685.06	5.06
IV	North Carolina	460	1.0	1100	10	1,571	11
VIII	North Dakota						
V	Ohio	20	0.048	53	0.48	73.528	0.528
VI	Oklahoma	5.6	0.013	14	0.13	19.743	0.143
X	Oregon	5.6	0.013	14	0.13	19.743	0.143
III	Pennsylvania	160	0.39	430	3.9	594.29	4.29
I	Rhode Island	130	0.30	330	3.0	463.3	3.3
IV	South Carolina	96	0.22	240	2.2	338.42	2.42
VIII	South Dakota						
IV	Tennessee	42	0.096	110	0.96	153.056	1.056
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	11	0.025	28	0.25	39.275	0.275
X	Washington						
III	West Virginia						
V	Wisconsin	11	0.025	28	0.25	39.275	0.275
VIII	Wyoming						
TOTAL		1,824.8	4.160	4,583	41.60	6,453.56	45.76
Region	I	300	0.689	756	6.89	1,063.579	7.579
	II	340	0.80	870	8.0	1,218.8	7.579
	III	171	0.415	458	4.15	633.565	8.8
	IV	871	1.927	2128	19.27	3,020.197	21.197
	V	78.6	0.182	205	1.82	285.602	2.002
	VI	5.6	0.013	14	0.13	19.743	0.143
	VII	11	0.025	28	0.25	39.275	0.275
	VIII						
	IX	42	0.096	110	0.96	153.056	1.056
	X	5.6	0.013	14	0.13	19.743	0.143

* Dry Weight ■ Wet Weight

Table 3-41. Category G – Quantities of Potentially Hazardous Wastewater Treatment Sludges From Yarn and Stock Dyeing and Finishing Operations, 1974

Region	State	RETAINED SLUDGES (KKG)* (NO WASTED SLUDGES)					
		Total Pot. Haz. Wastes		Total Heavy Metals	Total Chlorinated Organics	Dyestuff	Total Hazardous Constituents
		Dry $(\times 10^{-3})$	Wet	$(\times 10^{-6})$	$(\times 10^{-9})$	$(\times 10^{-3})$	$(\times 10^{-6})$
IV	Alabama	4.3	29	16	170	0.22	236
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	4.3	29	16	170	0.22	236
VIII	Colorado						
I	Connecticut	3.3	22	12	130	0.16	172
III	Delaware						
IV	Florida						
IV	Georgia	22	150	79	880	1.1	1,180
IX	Hawaii						
X	Idaho						
V	Illinois	4.3	29	16	170	0.22	236
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	1.1	7.5	4.0	44	0.055	59
VI	Louisiana						
I	Maine	1.1	7.5	4.0	44	0.055	59
III	Maryland						
I	Massachusetts	10	69	36	400	0.50	536
V	Michigan						
V	Minnesota	0.56	3.8	2.0	22	0.028	30
IV	Mississippi						
VII	Missouri	1.1	7.5	4.0	44	0.055	59
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	2.7	18	9.7	110	0.14	149.8
II	New Jersey	15	100	54	600	0.75	805
VI	New Mexico						
II	New York	20	130	72	800	1.0	1,073
IV	North Carolina	46	310	160	1,800	2.3	2,462
VIII	North Dakota						
V	Ohio	2.1	14	7.6	84	0.10	107.7
VI	Oklahoma	0.56	3.8	2.0	22	0.028	30
X	Oregon	0.56	3.8	2.0	22	0.028	30
III	Pennsylvania	17	120	61	680	0.85	912
I	Rhode Island	14	91	50	560	0.70	751
IV	South Carolina	9.8	66	35	390	0.49	525
VIII	South Dakota						
IV	Tennessee	4.3	29	16	170	0.22	236
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	1.1	7.5	4.0	44	0.055	59
X	Washington						
III	West Virginia						
V	Wisconsin	1.1	7.5	4.0	44	0.055	59
VIII	Wyoming						
TOTAL		186.28	1254.9	666.3	7,400	9.329	10,002.5
Region I		31.1	207.5	111.7	1,244	1.555	1,667.8
II		35	230	126	1,400	1.75	1,878
III		18.1	127.5	65	724	0.905	971
IV		87.5	591.5	310	3,454	4.385	4698
V		8.06	54.3	29.6	320	0.403	432.7
VI		0.56	3.8	2.0	22	0.028	30
VII		1.1	7.5	4.0	44	0.055	59
VIII							
IX		4.3	29	16	170	0.22	236
X		0.56	3.8	2.0	22	0.028	30

*See Table 3-8 for definition of retained and wasted sludge.

Table 3-42. Category G – Quantities of Potentially Hazardous Wastewater Treatment Sludges from Yarn and Stock Dyeing and Finishing Operations, 1977

		RETAINED SLUDGES* (KKG) (NO WASTED SLUDGES)					
		Total Pot. Haz. Waste					
		Total Dry ($\times 10^{-3}$)	Total Wet	Total Heavy Metals ($\times 10^{-6}$)	Total Chlorinated Organics ($\times 10^{-9}$)	Dyestuff ($\times 10^{-3}$)	Total Hazardous Constituents ($\times 10^{-3}$)
IV	Alabama	4.6	31	17	180	0.23	0.247
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	4.6	31	17	180	0.23	0.247
VIII	Colorado						
I	Connecticut	3.5	23	13	140	0.17	0.183
III	Delaware						
IV	Florida						
IV	Georgia	23	160	84	930	1.2	1.285
IX	Hawaii						
X	Idaho						
V	Illinois	4.6	31	17	180	0.23	0.247
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	1.2	8.0	4.2	47	0.058	0.062
VI	Louisiana						
I	Maine	1.2	8.0	4.2	47	0.058	0.062
III	Maryland						
I	Massachusetts	11	73	38	420	0.53	0.568
V	Michigan						
V	Minnesota	0.59	4.0	2.1	23	0.030	0.032
IV	Mississippi						
VII	Missouri	1.2	8.0	4.2	47	0.058	0.062
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	2.9	19	10	120	0.15	0.160
II	New Jersey	16	110	57	640	0.80	0.858
VI	New Mexico						
II	New York	21	140	76	850	1.1	1.177
IV	North Carolina	49	330	170	1800	2.3	2.47
VIII	North Dakota						
V	Ohio	22	15	8.1	89	0.11	0.118
VI	Oklahoma	0.59	4.0	2.1	23	0.030	0.032
X	Oregon	0.59	4.0	2.1	23	0.030	0.032
III	Pennsylvania	18	130	65	720	0.90	0.966
I	Rhode Island	15	96	53	590	0.74	0.784
IV	South Carolina	10	70	37	410	0.52	0.557
VIII	South Dakota						
IV	Tennessee	4.6	31	17	180	0.23	0.247
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	1.2	8.0	4.2	47	0.058	0.062
X	Washington						
III	West Virginia						
V	Wisconsin	1.2	8.0	4.2	47	0.058	0.062
VIII	Wyoming						
TOTAL		217.57	1,342	706.4	7,733	9.82	10.53
Region I		33.6	219	118.2	1,317	1.648	1.767
II		37	250	133	1,490	1.9	2.035
III		19.2	138	69.2	767	0.958	1.028
IV		92.4	630	329.2	3,547	4.538	4.868
V		28.39	58	31.4	339	0.428	0.459
VI		0.59	4	2.1	23	0.030	0.032
VII		1.2	8	4.2	47	0.058	0.062
VIII							
IX		4.6	31	17	180	0.23	0.247
X		0.59	4	2.1	23	0.030	0.032

* See Table 3-8 for definition of retained and wasted sludge.

Table 3-43. Category G - Quantities of Potentially Hazardous Wastewater Treatment Sludges From Yarn and Stock Dyeing and Finishing Operations,* 1983 (KKG/YR)

		Total Potentially Hazardous Wastes		Total Heavy Metals	Total Chlorinated Organics ($\times 10^{-3}$)	Dyestuff	Total Hazardous Constituents
		Dry	Wet ($\times 10^3$)				
IV	Alabama	590	236	2.1	24	30	32.1
X	Alaska						
IX	Arizona						
VI	Arkansas						
IX	California	590	2.36	2.1	24	30	32.1
VIII	Colorado						
I	Connecticut	460	1.84	1.6	18	23	24.6
III	Delaware						
IV	Florida						
IV	Georgia	3,000	12	11	120	150	161
IX	Hawaii						
X	Idaho						
V	Illinois	590	2.36	2.1	24	30	32.1
V	Indiana						
VII	Iowa						
VII	Kansas						
IV	Kentucky	160	0.64	0.58	6.4	8.0	8.59
VI	Louisiana						
I	Maine	160	0.64	0.58	6.4	8.0	8.59
III	Maryland						
I	Massachusetts	1,400	5.6	5.0	56	70	75.1
V	Michigan						
V	Minnesota	74	0.296	0.27	3.0	3.7	3.97
IV	Mississippi						
VII	Missouri	160	0.64	0.58	6.4	8.0	8.59
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	380	1.52	1.4	15	19	20.4
II	New Jersey	2,100	8.4	7.6	84	100	107.7
VI	New Mexico						
II	New York	2,800	11.2	10	110	140	150
IV	North Carolina	6,500	26	23	260	320	343
VIII	North Dakota						
V	Ohio	300	1.2	1.1	12	15	16.1
VI	Oklahoma	74	0.296	0.27	3.0	3.7	3.97
X	Oregon	74	0.296	0.27	3.0	3.7	3.97
III	Pennsylvania	2,500	10	9.0	100	120	129.1
I	Rhode Island	1,900	7.6	6.8	76	95	101.9
IV	South Carolina	1,400	5.6	5.0	56	70	75.1
VIII	South Dakota						
IV	Tennessee	590	2.36	2.1	24	30	32.1
VI	Texas						
VIII	Utah						
I	Vermont						
III	Virginia	160	0.64	0.58	6.4	8.0	5.59
X	Washington						
III	West Virginia						
V	Wisconsin	160	0.64	0.58	6.4	8.0	8.59
VIII	Wyoming						
TOTAL		26,122	104.488	93.61	1,044	1,293.1	1,387.26
Region I		4,300	17.2	15.38	171.4	215	230.59
II		4,900	19.6	17.6	194	240	257.7
III		2,660	10.64	9.58	106.4	128	137.69
IV		12,240	48.96	43.78	490.4	608	651.89
V		1,124	4.496	4.05	45.4	56.7	60.76
VI		74	0.296	0.27	3.0	3.7	3.97
VII		160	0.64	0.58	6.4	8.0	8.59
VIII							
IX		590	2.36	2.1	24	30	32.1
X		74	0.296	0.27	3.0	3.7	3.97

*It was not possible to differentiate between the retained and wasted sludge for 1983, so the estimated values for this year reflect the total quantity.

quantities to production. However, it is anticipated that 1983 regulations will bring about a change in methods of treatment. The best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount.

3.5 Total Waste Quantities in the Textiles Industry for 1974, 1977 and 1983

To properly interpret data in the tables of this section, the reader should be aware that not all digits are significant figures. Digits beyond the first two significant figures were entered simply as an aid in totalling columns, and should not be construed as having a higher degree of accuracy than is actually the case.

The estimated quantities of total wastes generated by the textiles industry for 1974, 1977 and 1983 appear in Table 3-44.

Total container wastes and potentially hazardous container residuals for 1974, 1977 and 1983 appear in Tables 3-45, 3-46 and 3-47, respectively. It should be noted that by cleaning the residual from these containers, this entire waste stream could be quickly, simply, and inexpensively rendered innocuous.

Total sludges and their potentially hazardous constituents for the years 1974, 1977 and 1983 appear in Tables 3-48, 3-49 and 3-50, respectively. Again, the best estimate of the effects of 1983 legislation was found in the report prepared for the National Commission on Water Quality entitled "Textile Industry Technology and Costs of Wastewater Control" (10). The figures for sludge generation in 1983 were based on the projected figures from this report. It was not possible to differentiate the amounts of retained and disposed of sludge for 1983 so the estimated values for this year reflect the total amount. Tables 3-44 through 3-50 were generated by simple addition of the quantities in corresponding tables found in Section 3.4 of this report.

3.6 Rationale for Determining Waste Streams for Technology and Cost Analysis

The land-destined waste streams considered potentially hazardous in this study are the textile dyeing and finishing plant wastewater treatment sludges, the dye containers with residual dyestuff and the chemical containers with residual chemical.

Table 3-44. Estimated Quantities of the Total Wastes Generated by the Textiles Industry (KKG/YR).

		1974		1977		1983	
		Dry	Wet	Dry	Wet	Dry	Wet
IV	Alabama	5,474	78,194	5,938	84,757	11,045	26,033
X	Alaska						
IX	Arizona						
VI	Arkansas	953	2,587	1,093	2,841	1,789	2,644
IX	California	10,590	13,814	11,980	15,509	19,601	31,168
VIII	Colorado	220	1,055	240	1,145	297	362
I	Connecticut	3,281+	38,674+	3,487+	40,884+	6,409+	16,481+
III	Delaware	179	3,562	194	3,774	294	604
IV	Florida	5,379	18,363	5,905	19,881	7,970	10,993
IV	Georgia	36,417	184,426	42,249	201,172	78,358	147,318
IX	Hawaii						
X	Idaho	64	67	70	74	119	233
V	Illinois	4,019	42,811	4,339	45,193	6,750	14,010
V	Indiana	861	5,850	965	6,255	1,451	2,238
VII	Iowa	417	651	437	673	864	2,229
VII	Kansas	240	1,831	261	1,953	356	553
IV	Kentucky	1,096	6,380	1,236	6,846	2,492	5,364
VI	Louisiana	440	451	481	492	722	1,179
I	Maine	2,307	14,266	2,364	14,532	5,226	15,900
III	Maryland						
I	Massachusetts	20,541	232,155	21,147	236,850	29,351	81,009
V	Michigan	1,549	5,244	1,691	5,586	2,699	5,146
V	Minnesota	1,288	3,252	1,386	3,458	2,223	4,498
IV	Mississippi	1,133	4,430	1,237	4,731	1,725	2,615
VII	Missouri	541	3,275	583	3,427	912	1,952
VIII	Montana	50	50	55	55	65	65
VII	Nebraska	400	400	438	438	521	521
IX	Nevada						
I	New Hampshire	2,121	13,079	2,204	13,900	4,636	13,568
II	New Jersey	24,988	154,060	26,446	165,728	33,682	73,445
VI	New Mexico	100	100	109	109	130	130
II	New York	33,630	90,270	36,547	96,395	53,218	92,398
IV	North Carolina	58,776	340,621	63,675	366,313	107,643	222,923
VIII	North Dakota						
V	Ohio	3,224	24,837	3,524	26,140	5,509	10,872
VI	Oklahoma	1,197	4,654	1,358	5,031	2,231	3,689
X	Oregon	1,497+	2,496+	1,571+	2,578+	2,827+	7,097+
III	Pennsylvania	23,382+	37,466+	25,383+	40,372+	39,618+	72,642+
I	Rhode Island						
IV	South Carolina	23,899+	464,908+	25,865+	496,824+	45,611+	108,141+
VIII	South Dakota						
IV	Tennessee	7,316	24,632	8,032	26,441	13,402	25,852
VI	Texas	9,883	94,795	10,134	97,040	10,203	26,921
VIII	Utah	530	773	590	835	1,123	2,416
I	Vermont	708	4,387	743	4,621	1,384	3,568
III	Virginia	3,809+	20,701+	4,112	22,029+	7,211+	15,664+
X	Washington	889	1,116	955	1,183	1,370	2,400
III	West Virginia	214	217	234	238	314	428
V	Wisconsin						
VIII	Wyoming						
TOTAL		310,173	2,098,575	336,274	2,221,399	533,602	1,120,759
Region I		38,328	353,689	39,633	358,924	59,930	165,640
II		52,618	244,330	56,992	262,122	86,900	165,843
III		28,193	70,915	30,588	76,133	47,999	91,324
IV		151,090	1,215,954	165,737	1,300,439	274,844	572,437
V		11,763	85,172	13,073	89,999	20,796	41,953
VI		12,573	102,587	13,174	105,513	15,076	34,564
VII		1,598	6,157	1,719	6,491	2,653	5,255
VIII		800	1,880	884	2,034	1,486	2,844
IX		10,590	13,814	11,280	15,509	19,601	31,168
X		2,450	3,680	2,596	3,835	4,317	9,731

+Waste quantities from Wool Scouring Operations not included, See Table 3-2.

Table 3-45. Total Quantity of Potentially Hazardous Dye and Chemical Container Wastes Generated by the Textile Industry, 1974 (KKG/YR) Dry Weight*

		Potentially Hazardous Dye and Chemical Containers	Hazardous Constituents
IV	Alabama	280	4.6
X	Alaska		
IX	Arizona		
VI	Arkansas	5	0.1
IX	California	170	1.2
VIII	Colorado	1	0.04
I	Connecticut	180	2.4
III	Delaware	5	0.17
IV	Florida	39	0.68
IV	Georgia	1060	13
IX	Hawaii		
X	Idaho	2	0.004
V	Illinois	180	2.8
V	Indiana	9	0.26
VII	Iowa	12	0.08
VII	Kansas	3	0.08
IV	Kentucky	52	0.51
VI	Louisiana	5	0.01
I	Maine	120	1.3
III	Maryland	15	0.43
I	Massachusetts	650	10
V	Michigan	23	0.3
V	Minnesota	36	0.29
IV	Mississippi	12	0.18
VII	Missouri	35	0.35
VIII	Montana		
VII	Nebraska		
IX	Nevada		
I	New Hampshire	140	1.4
II	New Jersey	780	10
VI	New Mexico		
II	New York	830	7.5
IV	North Carolina	2340	25
VIII	North Dakota		
V	Ohio	110	1.6
VI	Oklahoma	25	0.3
X	Oregon	49	0.39
III	Pennsylvania	690	4.8
I	Rhode Island	430	3.4
IV	South Carolina	1090	25
VIII	South Dakota		
IV	Tennessee	230	1.9
VI	Texas	86	1.9
VIII	Utah	10	0.08
I	Vermont	22	0.3
III	Virginia	120	0.63
X	Washington	9	0.07
III	West Virginia	2	0.004
V	Wisconsin	53	0.4
VIII	Wyoming		
TOTAL		9910	123
Region I		1550	19
II		1610	18
III		830	6
IV		5100	70
V		410	6
VI		120	2
VII		50	0.5
VIII		10	0.1
IX		170	1
X		60	0.4

* Dry Weight = Wet Weight

Table 3-46. Total Quantity of Potentially Hazardous Dye and Chemical Container Wastes Generated by the Textiles Industry, 1977 (KKG/YR) Dry Weight*

		Potentially Hazardous Dye and Chemical Containers	Hazardous Constituents
IV	Alabama	300	4.8
X	Alaska		
IX	Arizona		
VI	Arkansas	6	0.11
IX	California	190	1.2
VIII	Colorado	1	0.04
I	Connecticut	190	2.6
III	Delaware	6	0.18
IV	Florida	42	0.72
IV	Georgia	1150	13
IX	Hawaii		
X	Idaho	0.2	0.004
V	Illinois	190	2.9
V	Indiana	10	0.27
VII	Iowa	12	0.08
VII	Kansas	3	0.14
IV	Kentucky	55	0.54
VI	Louisiana	6	0.01
I	Maine	120	1.4
III	Maryland	16	0.45
I	Massachusetts	680	11
V	Michigan	23	0.31
V	Minnesota	38	0.35
IV	Mississippi	13	0.20
VII	Missouri	36	0.37
VIII	Montana		
VII	Nebraska		
IX	Nevada		
I	New Hampshire	150	1.5
II	New Jersey	730	11
VI	New Mexico		
II	New York	870	7.8
IV	North Carolina	2480	26
VIII	North Dakota		
V	Ohio	110	1.7
VI	Oklahoma	28	0.32
X	Oregon	51	0.40
III	Pennsylvania	730	5.0
I	Rhode Island	470	3.6
IV	South Carolina	1160	26
VIII	South Dakota		
IV	Tennessee	240	2.1
VI	Texas	90	2.0
VIII	Utah	10	0.08
I	Vermont	22	0.31
III	Virginia	120	0.60
X	Washington	9	0.07
III	West Virginia	2	0.004
V	Wisconsin	55	0.42
VIII	Wyoming		
TOTAL		10,414	130
Region I		1630	20
II		1600	19
III		870	6.2
IV		5440	74
V		430	6
VI		130	2.5
VII		52	0.5
VIII		12	0.1
IX		190	1.2
X		60	0.5

* Dry Weight = Wet Weight

Table 3-47. Total Quantity of Potentially Hazardous Dye and Chemical Container Wastes Generated by the Textiles Industry, 1983 (KKG/YR) Dry Weight*

		Potentially Hazardous Dye and Chemical Containers	Hazardous Constituents
IV	Alabama	360	5.8
X	Alaska		
IX	Arizona		
VI	Arkansas	10	0.14
IX	California	240	1.6
VIII	Colorado	2	0.05
I	Connecticut	220	3.0
III	Delaware	7	0.21
IV	Florida	49	0.87
IV	Georgia	1460	16
IX	Hawaii		
X	Idaho	2	0.005
V	Illinois	240	3.5
V	Indiana	13	0.33
VII	Iowa	13	0.08
VII	Kansas	3	0.11
IV	Kentucky	69	0.65
VI	Louisiana	7	0.01
I	Maine	130	1.5
III	Maryland	18	0.54
I	Massachusetts	790	13
V	Michigan	26	0.35
V	Minnesota	43	0.35
IV	Mississippi	16	0.23
VII	Missouri	44	0.43
VIII	Montana		
VII	Nebraska		
IX	Nevada		
I	New Hampshire	170	1.7
II	New Jersey	960	13
VI	New Mexico		
II	New York	880	9.3
IV	North Carolina	2910	30
VIII	North Dakota		
V	Ohio	130	2.0
VI	Oklahoma	35	0.39
X	Oregon	54	0.42
III	Pennsylvania	850	5.8
I	Rhode Island	540	4.2
IV	South Carolina	1380	32
VIII	South Dakota		
IV	Tennessee	290	2.4
VI	Texas	110	2.4
VIII	Utah	12	0.09
I	Vermont	23	0.34
III	Virginia	150	0.74
X	Washington	9	0.07
III	West Virginia	2	0.005
V	Wisconsin	65	0.48
VIII	Wyoming		
TOTAL		12,332	154
Region I		1873	23.4
II		1840	22.1
III		1027	7.4
IV		6534	88.1
V		517	7.1
VI		162	3
VII		60	0.6
VIII		14	0.2
IX		240	1.6
X		65	0.5

* Dry Weight = Wet Weight

Table 3-48. Total Quantity of Potentially Hazardous Wastewater Treatment Sludges Generated by the Textiles Industry, 1974.

Region	State	Retained Sludges (KKG) ** Total Dry	Total Wet	Total Heavy Metals (x 10^{-3})	Total Chlorinated Organics (x 10^{-6})	Dyestuff (x 10^{-3})	Total Hazardous Constituents (x 10^{-3})	Wasted Sludges (KKG/YR) ** Total Dry	Total Wet (x 10^{3})	Total Heavy Metals	Total Chlorinated Organics (x 10^{-3})	Dyestuff	Total Hazardous Constituents
IV	Alabama	0.97	161	7.64	30.9	48.4	56	610	72	5.7	9.1	30	35.7
X	Alaska												
IX	Arizona												
VI	Arkansas	0.018	14.7	0.164	0.3	0.9	1.1	14	1.6	0.13	0.21	0.70	0.83
IX	California	0.17	165	0.96	8.9	8.4	9.4	14	1.6	0.13	0.21	0.70	0.83
VIII	Colorado	0.0076	0.87	0.07	0.11	0.38	0.45	7.2	0.84	0.065	0.11	0.36	0.395
I	Connecticut	0.37+	92.7+	3.2+	8.2+	19.0+	22.2+	290+	34+	2.7+	4.4+	14+	16.7+
III	Delaware	0.031	3.5	0.29	0.47	1.6	1.89	29	3.4	0.27	0.44	1.4	1.67
IV	Florida	0.21	33.6	1.51	8.24	10.6	12.1	110	13	0.13	1.7	5.5	5.63
IV	Georgia	1.82	970	15	47.5	91.1	106	1200	140	12	19	60	72
IX	Hawaii												
X	Idaho	0.01	1.5	0.05	0.65	0.5	0.55						
V	Illinois	0.39	74.1	3.4	8.1	19.3	22.7	320	38	3.0	4.9	16	19
V	Indiana	0.05	10.8	0.44	0.74	2.4	2.8	44	5.0	0.41	0.65	2.2	2.61
VII	Iowa	0.022	10.6	0.11	1.4	1.0	1.1						
VII	Kansas	0.02	1.7	0.14	0.22	0.75	0.89	14	1.6	0.13	0.21	0.70	0.83
IV	Kentucky	0.11	34.9	0.78	4.88	5.7	6.5	44	5.0	0.41	0.65	2.2	2.61
VI	Louisiana	0.03	4.6	0.16	2.1	1.6	1.8						
I	Maine	0.11	82	1.0	2.1	5.4	6.4	84	9.8	0.78	1.3	4.2	4.98
III	Maryland	0.09	10.2	0.75	1.75	4.3	5.0	72	8.4	0.65	1.1	3.6	3.95
I	Massachusetts	3.5	374	23	33.1	74.1	97.1	8600	214	50	27.1	60	110
V	Michigan	0.04	23.6	0.37	1.16	2.2	2.6	29	3.3	0.27	0.44	1.4	1.67
V	Minnesota	0.069	20.8	0.42	3.6	3.5	3.9	14	1.6	0.13	0.21	0.70	0.83
IV	Mississippi	0.07	9.6	0.5	3.2	3.7	4.2	29	3.3	0.27	0.44	1.4	1.67
VII	Missouri	0.024	10.1	0.22	0.39	1.3	1.5	21	25	0.20	0.32	1.0	1.2
VIII	Montana												
VII	Nebraska												
IX	Nevada												
I	New Hampshire	0.14	75.3	1.14	4.8	7.2	8.3	78	9.1	0.072	1.2	3.9	3.97
II	New Jersey	1.64	373	13.3	45.6	82.0	95.4	1100	130	10	17	55	65
VI	New Mexico												
II	New York	1.23	381	8.22	55.9	61.5	69.7	440	50	4.1	6.5	22	26.1
IV	North Carolina	5.96	1181	40.3	252	293	333	2400	270	23	36	120	143
VIII	North Dakota												
V	Ohio	0.24	55.3	2.04	5.72	11.8	13.8	180	21	1.7	2.7	9.0	1.16
VI	Oklahoma	0.045	21.8	0.37	1.22	2.28	2.64	29	3.3	0.27	0.44	1.4	1.67
X	Oregon	0.013+	33.3+	0.1+	0.67+	0.64	0.74+	*	*	*	*	*	*
III	Pennsylvania	0.79+	330+	4.38+	46.9+	40	44.3+	65+	7.8+	0.61+	0.98+	3.2+	3.81+
I	Rhode Island	0.18+	153+	1.25+	7.7+	9.1	10.3+	65+	7.8+	9.61+	0.98+	3.2+	3.81+
IV	South Carolina	4.75+	684+	41.4+	104+	233	274	3800+	440+	36+	58+	190+	225+
VIII	South Dakota												
IV	Tennessee	0.56	137	3.5	28.5	28.0	31.5	140	16	1.3	2.1	7.0	8.3
VI	Texas	1.36	88.1	8.17	8.8	18.3	26.5	5900	90	31.8	11.8	15	46.8
VIII	Utah	0.002	13.2	0.023	0.037	0.1	0.12						
I	Vermont	0.04	18	0.36	1.1	2.2	2.5	29	3.3	0.27	0.44	1.4	1.67
III	Virginia	0.37+	82.1+	2.55+	16.3+	18.7	21.2+	140+	16+	1.3+	2.1+	7.0+	8.3+
X	Washington	.0006	7.6	0.012		0.03	0.042						
III	West Virginia	0.01	1.5	0.05	0.65	0.5	0.55						
V	Wisconsin	0.08	26	0.48	4.4	4.0	4.5	14	1.6	0.13	0.21	0.70	0.83
VIII	Wyoming												
TOTAL		29.9	5800	203.4	756.6	1117	1321	38,400	1750	121,000	230	645	900
Region I		5.3	1000	36	134	198	234	12,446	401	71,436	40.32	86.7	158.2
II		2.9	560	20	73	108	128	1540	180	14.1	23.5	7.7	91.1
III		2.3	440	16	58	86	102	7706+	109.6+	41.83+	13.72+	15.2	57+
IV		15.8	3100	107	400	591	698	15,733+	1033.3+	117.81+	136.09+	416.1	498+
V		0.9	170	6.1	23	33.7	40	601	70.5	5.64	9.11	30	35.8
VI		1.4	280	9.5	35	62	62	5943	94.9	32.2	12.45	17.1	49.3
VII		0.06	12	0.41	1.5	2.2	2.6	35	4.1	0.33	0.53	1.7	2.03
VIII		0.01	3	0.068	0.2	0.4	0.4	7.2	0.84	0.065	0.11	0.36	0.425
IX		0.38	35	1.2	4.6	6.7	8.0	14	1.6	0.13	0.21	0.70	0.83
X		1.05	200	7.1	26	39	46	1000+	10+	9+	2+	—	9+

* Data withheld due to its proprietary nature

\+ Waste quantities from Wool Scouring Operations not included, see Table 3-2

** See Table 3-8 for definition of retained and wasted sludge

Table 3-49. Estimated Total Quantity of Potentially Hazardous Wastewater Treatment Sludges Generated by the Textiles Industry, 1977.

Region	State	Retained Sludges (KKG)** Total Dry	Retained Total Wet	Retained Total Heavy Metals ($\times 10^{-3}$)	Retained Total Chlorinated Organics ($\times 10^{-6}$)	Retained Dyestuff ($\times 10^{-3}$)	Retained Total Hazardous Constituents ($\times 10^{-3}$)	Wasted Sludges (KKG/YR)** Total Dry	Wasted Total Wet ($\times 10^{3}$)	Wasted Total Heavy Metals	Wasted Total Chlorinated Organics ($\times 10^{-3}$)	Wasted Dyestuff	Wasted Total Hazardous Constituents
IV	Alabama	1	160	7.7	32	49	57	650	78	6	9.8	32	36
X	Alaska												
IX	Arizona												
VI	Arkansas	0.02	18	0.17	0.32	0.94	1.1	15	1.7	0.14	0.23	0.75	0.89
IX	California	0.18	200	1.1	9.6	9.2	10	15	1.7	0.14	0.23	0.75	0.89
VIII	Colorado	0.01	0.87	0.07	0.11	0.38	0.45	7.8	0.91	0.07	0.12	0.39	0.46
I	Connecticut	0.37+	96+	3.2+	8.4+	19	22+	310	36	2.9	4.7	16	19
III	Delaware	0.03	3.5	0.29	0.47	1.6	1.9	31	3.6	0.29	0.47	1.6	1.9
IV	Florida	0.22	36	1.5	9.1	11	12	120	14	1.1	1.8	6.0	7.1
IV	Georgia	1.9	1100	15	49	94	110	1300	150	12	20	65	77
IX	Hawaii												
X	Idaho	0.01	1.6	0.05	0.69	0.53	0.58						
V	Illinois	0.39	76	3.4	8.3	19	23	340	40	3.2	5.3	17	20
V	Indiana	0.05	12	0.44	0.75	2.4	2.8	46	5.3	0.44	0.72	2.3	2.7
VII	Iowa	0.02	11	0.12	1.5	1.1	1.2						
VII	Kansas	0.02	1.7	0.14	0.22	0.75	0.89	15	1.7	0.14	0.23	0.75	0.89
IV	Kentucky	0.12	33	0.8	5.1	6.7	6.8	46	5.3	0.44	0.72	2.3	2.7
VI	Louisiana	0.03	4.9	0.17	2.2	1.7	1.9						
I	Maine	0.11	87	1	2.1	5.4	6.5	91	10	0.84	1.4	4.6	5.4
III	Maryland	0.09	10	0.75	1.8	4.3	5.1	78	9.1	0.72	1.2	3.9	4.6
I	Massachusetts	3.5	390	23	76	75	98	8600	214	51	28	60	110
V	Michigan	0.04	19	0.58	1.2	2.3	26	31	3.5	0.28	0.46	1.5	1.8
V	Minnesota	0.08	22	0.45	3.8	3.7	3.3	15	1.7	0.14	0.23	0.75	0.89
IV	Mississippi	0.08	10	0.44	34	3.8	4.3	30	3.5	0.28	0.46	1.5	1.8
VII	Missouri	0.02	11	0.22	0.4	1.3	1.5	23	2.6	0.21	0.34	1.2	1.4
VIII	Montana												
VII	Nebraska												
IX	Nevada												
I	New Hampshire	0.15	79	1.2	5	7.4	7.8	84	9.8	0.08	1.2	4.2	4.3
II	New Jersey	1.7	390	13	48	83	97	1200	140	11	18	60	71
VI	New Mexico												
II	New York	1.3	410	8.4	59	64	73	460	53	4.4	7.2	23	27
IV	North Carolina	6.2	1200	41	260	300	340	2500	290	24	38	125	149
VIII	North Dakota												
V	Ohio	0.26	59	2.1	5.9	12	14	200	22	1.8	2.9	10	12
VI	Oklahoma	0.05	25	0.38	1.3	2.4	2.7	30	3.5	0.28	0.46	1.5	1.8
X	Oregon	0.01+	360+	0.1+	0.7+	0.68	0.75+	*	*	*	*	*	*
III	Pennsylvania	0.83+	360+	4.6+	50+	50	47+	72	8.4	0.65	1.0	3.6	4.2
I	Rhode Island	0.19+	160+	1.3+	8.1+	9.4	11+	72	8.4	0.65	1.0	3.6	4.2
IV	South Carolina	4.8+	710+	42+	110+	240	600+	4000	470	38	62	200	238
VIII	South Dakota												
IV	Tennessee	0.58	150	3.6	31	29	33	150	17	1.4	2.3	7.5	8.9
VI	Texas	1.4	92	8.2	9	18	27	5920	92	32	12	16	48
VIII	Utah	0.002	15	0.03	0.05	0.12	0.14						
I	Vermont	0.04	19	0.36	1.2	2.2	2.5	30	3.5	0.28	0.46	15	1.8
III	Virginia	0.4+	87+	2.7+	17+	20	22+	150	17	1.4	2.3	7.5	8.9
X	Washington	0.0006	8.1	0.01	Nil	0.03	0.04						
III	West Virginia	0.01	1.6	0.05	0.69	0.53	0.58						
V	Wisconsin	0.08	28	0.5	4.6	4.2	4.7	15	1.7	0.14	0.23	0.75	0.89
VIII	Wyoming												
TOTAL		29	6300	206	790	1150	1350	39,100	1840	260	240	680	940
Region I		5.4	814	36	60	117	55	12,500	315	73	42	90	160
II		2.9	831	22	107	147	169	1660	193	15	25	83	98
III		2.3	473	13	72	68	82	3730	72	22	9	17	39
IV		16	3500	118	498	732	849	12,800	1070	200	140	440	540
V		0.9	223	7.3	25	44	51	646	74	6	9.8	32	38
VI		1.5	140	8.9	13	23	32	5965	97	32	13	18	51
VII		0.06	24	0.5	1	3.1	3.6	38	4.2	0.35	0.57	2	2.3
VIII		0.01	16	0.1	0.2	0.5	0.6	7.8	0.9	0.07	0.12	0.4	0.46
IX		0.18	200	1.1	9.6	9.2	10	15	1.7	0.14	0.23	0.8	0.89
X		1.0	49	5.7	2.7	1.2	6.4	1000+	10+	9+	2+		9+

* Data withheld due to its proprietary nature

** See Table 3-8 for definition of retained and wasted sludge

\+ Waste quantities from Wool Scouring Operations not included, see Table 3-2

Table 3-50. Estimated Total Quantity of Potentially Hazardous Wastewater Treatment Sludges Generated by the Textiles Industry, 1983

		SLUDGES (KKG)					
		Total Potentially Hazardous Waste		Total Heavy Metals	Total Chlorinated Organics (x 10^{-3})	Dyestuff	Total Hazardous Constituents
		Dry (x 10^3)	Wet (x 10^3)				
IV	Alabama	4.5	18	32	160	230	260
X	Alaska						
IX	Arizona						
VI	Arkansas	0.26	1.04	2.2	6.1	13	15
IX	California	3.1	12.4	24	103	160	180
VIII	Colorado	0.02	0.08	0.2	0.32	1	1.2
I	Connecticut	2.8 +	11.2 +	33 +	49 +	140	170
III	Delaware	0.1	0.4	1	1.6	5	6
IV	Florida	1	4	6.8	40	48	55
IV	Georgia	19	76	160	520	950	1100
IX	Hawaii						
X	Idaho	0.04	0.16	0.2	2.4	1.8	2
V	Illinois	2	8	15	55	100	115
V	Indiana	0.25	1	2.2	4.7	12	15
VII	Iowa	0.38	1.52	6.3	7.1	20	26
VII	Kansas	0.06	0.24	0.6	1	3.2	3.8
IV	Kentucky	0.83	3.32	5.3	33	41	47
VI	Louisiana	0.15	0.6	0.75	9.7	7.5	8.2
I	Maine	2.8	11.2	51	14	150	200
III	Maryland	0.32	1.28	2.8	6.6	16	19
I	Massachusetts	15	60	160	180	540	690
V	Michigan	0.68	2.72	12	6.2	34	45
V	Minnesota	0.63	2.52	7.7	18	32	40
IV	Mississippi	0.29	1.16	1.9	14	14	16
VII	Missouri	0.24	0.96	1.4	7.7	12	14
VIII	Montana						
VII	Nebraska						
IX	Nevada						
I	New Hampshire	2.3	9.2	35	34	120	150
II	New Jersey	11	44	110	270	550	660
VI	New Mexico						
II	New York	10	40	96	350	510	610
IV	North Carolina	33	132	230	1600	1700	1900
VIII	North Dakota						
V	Ohio	1.5	6	14	36	74	89
VI	Oklahoma	0.41	1.64	3	12	20	23
X	Oregon	1.1 +	4.4 +	20 +	5.5 +	54	75 +
III	Pennsylvania	8.8 +	35.2 +	83 +	320 +	430	520 +
I	Rhode Island	3.9	15.6 +	41 +	110 +	200	240 +
IV	South Carolina	19 +	76 +	170 +	460 +	950	1100 +
VIII	South Dakota						
IV	Tennessee	3.6	14.4	25	160	180	200
VI	Texas	5.3	21.2	45	38	110	150
VIII	Utah	0.35	1.4	6.3	2.1	18	24
I	Vermont	0.6	2.4	11	4	30	41
III	Virginia	2.5 +	10 +	26 +	79 +	120	150 +
X	Washington	0.27	1.08	5.7	0.03	14	20
III	West Virginia	0.04	0.16	0.2	2.4	1.8	2
V	Wisconsin	0.83	3.32	8.8	27	42	51
VIII	Wyoming						
TOTAL		167	668	1500	2500	7700	9200
Region I		29	116	340	390	1200	1500
II		21	84	210	620	1200	1400
III		14	56	120	410	580	700
IV		84	336	640	2800	4100	4700
V		5.9	23.6	60	150	290	350
VI		6.1	24.4	50	66	150	200
VII		0.7	2.8	8.2	16	35	43
VIII		0.4	1.6	6.5	2.4	19	26
IX		3.1	12.4	24	100	160	180
X		2.4	9.6	32	9.1	70	100

+Waste quantities from Wool Scouring Operations not included, see Table 3-2.

3.6.1 Potentially Hazardous Waste Streams *

3.6.1.1 Wastewater Treatment Sludge

The first waste stream worthy of study is the sludge arising from the treatment of textile mill effluents. Wastewater treatment sludges are the most complex waste from dyeing and finishing mills, and includes such components as heavy metals, adsorbed dyes and chemicals, and chemical and biological solids. While this waste stream contains some hazardous components (heavy metals, residual and adsorbed dyestuffs and chlorinated organics), it also contains a significant percentage of non-hazardous constituents, such as common salt, sodium sulfate, and chemical and biological solids.

Heavy metal concentrations present in wastewater treatment sludges were found from samples in all categories except C, Greige Goods, to exceed drinking water limits. The total heavy metals found in the various categories range from 3,606 ppm in Yarn and Stock Dyeing and Finishing to 20,990 ppm in Wool Fabric Dyeing and Finishing. Average concentration ranges for various metals of concern (see Section 3.2) found in analyzed sludges are given below.

Metal	Range of Average Concentration, ppm	Drinking Water Limit, ppm
As	<0.1 to <17	0.05
Cd	1.2 to <17	0.01
Co	4.2 to 212	0.2*
Cr	19 to 1,196	0.05
Cu	18 to 652	1.0
Fe	1,000 to 5,200	0.3
Pb	<25 to <170	0.05
Zn	106 to 2,370	5.0

* Limit for agricultural waters

The bulk of the heavy metals which end up in land-destined sludges are washed or rinsed from fabric into the mill's wastewater treatment system from such operations as scouring incoming greige goods, dyeing cloth, and applying various finishes. The free metal ions may then be adsorbed onto the biological (or chemical) sludge generated in aeration ponds. Any metal which is structurally chelated within a dye is not free to leach from the landfilled sludge unless degradation of the dye occurs. Once this happens, however, the bound metals are released and can leach through soils and eventually reach an aquifer or ground water. There is also the possibility of ion exchange occurring if free cations such as Fe^{+2} or Fe^{+3} are available. This further increases the probability of other heavy metals reaching ground water supplies in significant quantities.

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

Dyestuffs are also considered a hazardous component of wastewater treatment sludges because they present the environment hazards cited in Section 3.2. These hazards include toxicity and non-biodegradability problems as well as the possibility of anaerobic degradation of dyes in a sanitary landfill to toxic or carcinogenic intermediates.

Residual organics are also a hazardous component of textile sludges.

The analysis of sludges for specific organic compounds was beyond the scope of this study. However, total chlorinated organics were identified. The analyses from all subcategories except C showed total chlorinated organics present in sludges ranging in value from 0.11 to 64.7 ppm. The drinking water limit for total organics is 0.7 ppm, and the average values for each category exceeded this limit. Since the number and variety of these dyeing and finishing chemicals is so large and in the light of the concern generated by recently completed and ongoing studies (26, 27, 28) of organic compounds as wastewater pollutants, we include these chemicals as being hazardous constituents found in wastewater treatment sludges.

3.6.1.2 Dye Containers

The second land-destined waste stream considered potentially hazardous is the dye containers and the residual dyestuff contained therein. A discarded dye container carries approximately 28 to 56 g (1 to 2 oz) of residual dyestuff to the disposal site, which in these industries is often a county or municipal landfill. The residual dyestuff which ended up in a landfill for the year 1974 amounted to 11.7 kkg, and this figure is projected to increase to 12.5 kkg for 1977 and 14.8 kkg for 1983. The dyestuff component of this waste stream presents the same environmental hazards cited in Section 3.2 (i.e., toxicity and biodegradability hazards and the possibility of anaerobic degradation of dyes in a landfill to toxic or carcinogenic metabolites). Therefore, as stated in Section 3.2, all dye-bearing waste streams are considered potentially hazardous.

3.6.1.3 Chemical Containers

The third potentially hazardous waste stream includes chemical bags or drums containing residual chemicals. Such items as dichromate salts (oxidizing agents); sodium hydrosulfite (reducing and stripping agent); zinc nitrate and magnesium chloride (catalysts); polyvinyl chloride, tetrakis (hydroxymethyl) phosphonium chloride, chlorinated paraffins and organic phosphorus compounds (flame retardants); silicofluoride compounds, sodium pentachlorophenate and phenylsulfonic acid derivatives (mothproofing agents); and urea-formaldehyde, dihydroxydichlorodiphenylmethane, mixture of zinc salts of dimethyldithiocarbamic acid, 2-mercaptobenzothiazole, and copper naphthalene (mildewicides) come in bags or drums. Any of these materials which reach a landfill in discarded packaging present a potential hazard as cited in Section 3.2, for processing chemicals from dyeing and finishing mills.

The amount of residual hazardous chemicals which reach landfill sites in discarded packaging amounted to 111.7 kkg in 1974 and is projected to increase to 117.4 kkg in 1977, and 139 kkg in 1983. Because of the multitude and variety of heavy metal containing chemicals and chlorinated organic chemicals used in the textiles industry and known persistency and possible toxicities of some of them, chemical containers were considered a potentially hazardous waste stream warranting further study.

3.6.1.4 Other Potentially Hazardous Wastes

The contractor also found isolated and atypical instances of potentially hazardous wastes such as solvent wastes and still bottoms from specialized processes and yarn and lint wet with non-fixed dye and dye-assist chemicals. Quantities of these wastes may be found in Table 4-4. Solvent wastes and still bottoms containing such materials as acetone (flashpoint 15F), methanol (flashpoint 65F), naphtha (flashpoint 20-110F) are extremely volatile organic solvents and present flammability hazards when stored in quantity. Thus, referring to Section 3.2 for the DOT flashpoint criteria, this waste stream, when it occurs, is considered potentially hazardous. This type of waste is associated with specialty operations such as tricot and lace splitting or solvent scouring.

Yarn and fiber wet with non-fixed dye and dye-assist chemicals were found in one facility dyeing and finishing tufted carpets. The only other area where this could be a problem is yarn and stock dyeing, and no evidence was found that it is a problem. If this wet yarn and lint is combined with other mill trash and sent to a landfill with no attempt made to remove excess dye liquor or chemical, the problem arises of the dye or excess chemical leaching to the landfill environment. For the reasons cited in Section 3.2 pertaining to dyes and other chemicals, this waste is considered potentially hazardous and will also be discussed on an individual basis.

In summary, the following waste streams are considered potentially hazardous for the purpose of this study:

Waste Stream and Hazardous Constituents	Criteria for Determining Hazardousness
Wastewater treatment sludges with absorbed dyestuff, heavy metals and chlorinated organic chemicals	ADMI studies; Drinking Water Standards for metals and total organics
Dye containers with residual dyestuff	ADMI studies (14)
Chemical containers with residual chemicals	Drinking Water Standards for metals and total organics
Atypical solvent and still bottom wastes	DOT Flashpoint Standard (100F) (25) Drinking Water Standards for total organics
Fiber wet with dye and dye-assist chemicals	ADMI studies; Drinking Water Standards for total organics

3.6.2 Non-Hazardous Waste Streams

Initially there was concern that waste dyed fibers and rags from seam and selvage trim might warrant classification as potentially hazardous in the event that the dye might leach into the landfill, posing environmental hazards. Dyes, however, are generally formulated to be lightfast and washfast. Industry contacts have indicated that when dye is affixed to a fiber and no excess remains, only under contact with chemical stripping agents, which is highly improbable in a landfill, might the fixed dye be leached or released from dyed fiber. Normal acidic landfill conditions will not release affixed dye from fiber.

Fly, flock, and cotton dust, due to their fine particulate natures, are usually handled and landfilled in containers such as polyethylene or polypropylene bags or cardboard boxes. As a result, these present little fire or explosion hazard during or after landfilling.

While it has been shown that increased exposure to cotton dust has been associated with an increase in the prevalence of byssinosis in textile mill workers (29), exposures for personnel involved with the management of these wastes (landfill operators, waste collectors) are both brief and intermittent. The cotton waste handling and disposal methods employed (containerized) reduce the risks of contracting byssinosis even further. The possibility of harming human health through ingestion of cotton dust was dismissed after contacting experts (30, 31) who reported there is no evidence that any disease can be caused by ingestion of cotton dust. In addition, the cellulosic structure of cotton is extremely biodegradable and the possibility of cotton dust in leachate from a landfill reaching an aquifer is very slight. For these reasons, landfilled cotton wastes are classified as non-hazardous.

There was also some concern about latex wastes because of the position the state of Georgia (32) has taken on the handling and disposition of such wastes. A 1971 leachate study by Roy F. Weston (33) on landfilled latex wastes showed a small percentage of dissolved zinc (0.0039 per cent by weight of the dry latex cake). Thus a latex cake dewatered to 30 per cent solids would have 1.3 ppm of zinc which could leach from the cake under the stated study conditions. This is less than the drinking water limit of 5 ppm for zinc. This leaching occurred under the following conditions: the latex with a normal pH of 11.2 was subjected to acid landfill conditions and 26 consecutive days of intimate water contact. No subsequent studies have been undertaken to confirm and expand this finding and, as such, the results are inconclusive. The state of Georgia has taken a conservative stance and requires dewatering and segregation of latex in a sanitary landfill (34) because of the high concentration (60 per cent of production) of the carpet industry centered in Georgia contributing significant amounts of latex wastes to state, county, and municipal landfills. However, the state of California, for example, does not consider latex wastes to be potentially hazardous.

The problem of zinc in latex occurs only in natural and synthetic latex foams using sulfur crosslinking for curing and requiring zinc oxide as a curing aid. Latex foams represent about 18 per cent of the backings used in the carpet industry. The amount of zinc oxide used is approximately 5 parts per 100 of dry latex. Thus, since the amount of zinc shown to leach (1.3 ppm) is well within the drinking water limit, in the absence of any conclusive leachate studies and the stance of other states on the subject, we are considering dewatered latex to be non-hazardous.

For the reasons cited above, we are considering the following waste streams as non-hazardous:

dry, dyed fabric, stock and yarn

flock from mechanical finishing of cloth (shearing, sueding, etc.)

fly (including cotton dust) which may or may not be dyed, from carding picking, spinning, weaving, knitting

rags from seam and selvage trimming

latex

4.0 TREATMENT AND DISPOSAL TECHNOLOGY

4.1 Introduction

Land-destined potentially hazardous wastes from the textile industry are of two principal types depending on their origin -- process wastes, and wastewater treatment wastes. Both types of wastes are the result of dyeing and finishing operations; i.e., if there are no dyeing or finishing operations at a textile plant, then there are usually no potentially hazardous land-destined wastes. The exception to this is the wastewater treatment sludge from wool scouring operations which contains both heavy metals and chlorinated organics.

Potentially hazardous process wastes consist mainly of residual dyes and chemicals in drums and bags. Other potentially hazardous process waste materials found in 5 to 20 per cent of the plants are lint, yarn and fabric having excess non-fixed dye, flammable solvents and solvent sludges. With the exception of the solvents, these wastes are solid, fairly low in moisture content and are handled as part of plant trash.

Wastewater form textile plants in all industry categories except Greige Goods contain various organic substances, which may or may not be biodegradable. Textile plants either treat this wastewater biologically or discharge without treatment to a municipal sewer which in turn treats the wastewater with activated sludge. In either case the sludge builds up in the system and the excess has to be wasted. Both residual organics and heavy metals concentrate in this sludge and are the potentially hazardous components. These sludge wastes are high in moisture content even after filtration or centrifuging and are handled separately from plant trash.

Aside from moisture content, process wastes differ markedly from wastewater treatment wastes:

- Process wastes can be reduced or eliminated through housekeeping and segregation practices whereas wastewater treatment sludges cannot.
- Plant wastewater effluents contain some of the wastewater treatment sludge as suspended solids, whereas all solid process wastes are land disposed or sold.
- The composition of process wastes can usually be estimated with confidence, whereas treatment system sludge compositions are largely unknown.

In general, neither type of waste is currently considered to be hazardous by the textile industry. Therefore, the current treatment and disposal technology reflects this viewpoint. Process wastes are usually combined with the plant trash, and wastewater treatment sludges are disposed of with no special precautions.

A great deal of attention has been devoted to wastewater in this industry, but very little to land disposed wastes.

4.2 Waste Management Practices in the Textile Industry

The following waste management practices pertinent to land disposal were found to be currently used in the textile industry.

4.2.1 Control Practices

To avoid sending residual dyestuffs and chemicals to disposal, many plants send returnable drums back to the supplier, others wash out the drums. Waste lint, yarn and fabric containing excess dye solution are sometimes segregated from other solid wastes and disposed of separately. This segregation, while not used for isolation of potentially hazardous wastes, constitutes a first step in applying any future treatment/disposal technology.

4.2.2 Lagoon Storage or Retention of Sludges

Wastewater treatment sludges are now being stored or retained in the wastewater treatment systems, either in disposal ponds or in the bottom of ponds or lagoons that are used for aeration and activated sludge treatment. As this sludge builds up, it will eventually reach the level where other storage or disposal will become necessary.

4.2.3 Land Dumping

Disposal by land dumping of both wastewater sludges and process wastes is practiced by some textile plants. Sometimes the dumping of sludges is on-site. Usually process wastes go to local public facilities.

4.2.4 Land Spreading

Wastewater treatment sludges have some fertilizer value. Therefore, these sludges in some instances are being sprayed or spread on land. Various techniques are used, often utilizing farm-type equipment or irrigation-type spray units.

4.2.5 General Purpose Landfills

Some of the wasted sludge and most of the process wastes go into general purpose landfills. General purpose landfills are characterized by their acceptance of a wide variety of wastes, including garbage and other organic materials, and usually by the absence of special containment, monitoring, and leachate treatment provisions. General purpose landfills are environmentally inadequate for disposal of hazardous wastes because their use for this purpose may lead to contamination of both surface and ground water in the area.

4.2.6 General Purpose Approved Landfills

Only one instance was encountered where an approved landfill was used for the disposal of potentially hazardous textile industry wastes. A plant disposed of dewatered sludge in an approved landfill in EPA Region III. An approved general purpose landfill is defined to meet the following criteria:

(1) The composition and volume of each hazardous waste is known and approved for site disposal by pertinent regulatory agencies.

(2) The site is suitable for hazardous wastes.

(3) Provision is made for monitoring wells and leachate control and treatment if required.

The advantages of approved landfill sites include:

(1) Many potentially hazardous wastes may be disposed of in a controlled and environmentally safe fashion.

(2) Approved landfills are more readily available than secured landfills.

(3) Disposal costs for transporting to the site and landfilling are closer to those for general purpose sites than for secured landfills.

General purpose approved landfills differ from general purpose landfills in construction by having (1) an impermeable barrier to retain leachate, (2) monitoring installations to make sure of the barrier integrity, and, (3) leachate control and treatment facilities, if needed. The following are types of general purpose approved landfills:

(1) Impermeable natural clay or rock basins in dry climates where leachate may be contained without collection, treatment or disposal. These sites are usually found in the arid southwestern and western parts of the U.S.

(2) Impermeable basins lined with clay, asphalt, plastic, rubber, concrete or other material in dry climates where runoff control is necessary.

Many landfill areas currently labelled as "approved" do not conform to the definition given above. All references to "approved landfills" in this report pertain to facilities with the safeguards listed and not to local terminology.

4.2.7 Incineration

A few textile industry plants incinerate process wastes. There are two areas of potentially hazardous pollution involved in incineration -- air pollution and contaminated ash containing dye and chemical carrier residues and leachable heavy metals. The air emissions probably do not differ greatly from those of incinerating municipal trash or activated sludge, since the dyes and chemicals usually constitute a minor portion of the wastes. Therefore air pollution abatement facilities of normal capabilities will be required. However, ash from the incinerator will probably contain significant quantities of heavy metal contaminants, and should be considered a potentially hazardous material. Disposal of the ash in an approved landfill ought to be environmentally adequate. Chemical treatment, fixation and encapsulation are other potential alternative treatments for land disposal. Most plants in the textile industry, however, do not incinerate process or wastewater treatment wastes because of the high costs of environmentally adequate incineration equipment and the high cost of fuel.

4.2.8 Wet Oxidation

At least one plant is known to have installed a wet oxidation process for treatment of wastewater sludge. This process, which uses liquid phase oxidation of wastes at high temperatures and pressures, has the operational flexibility of achieving either partial or nearly complete oxidation, as needed. Wet oxidation reduces the amount of sludge and makes the remaining sludge easier to dewater. It also converts much of the non-biodegradable organic material (measured as COD) to either oxidized innocuous components or biologically degradable material which can be recycled to the plant wastewater treatment system for destruction. This operation has not been in use since 1972 because the small amount of sludge generated in the wastewater treatment system makes the equipment uneconomical to operate.

4.2.9 Reclaiming

Potentially hazardous wastes of an atypical nature found in a small portion of the textile plants visited are sometimes reclaimed. Most of these wastes contain organic solvents, either from still bottoms or from solvent solutions used in finishing operations for impregnation or coating of the textile fibers. The solvent component of this atypical waste is reclaimed by contractors specializing in waste recovery.

4.3 Current Hazardous Waste Management Practices

Table 4-1 summarizes the treatment and disposal practices currently employed by the textile plants studied.

4.3.1 Category A - Wool Scouring

Category A plants do not generate dye and chemical container wastes.

Three of the four plants visited have wastewater treatment facilities, one of which sends their overflow from the sludge basin to municipal treatment. The fourth plant discharges without treatment. Two of the three plants that retain sludge have concrete lined retention basins.

Table 4-1. Summary of Treatment/Disposal Practices at Visited Textile Plants

Category/ Plant	EPA Region	Discharge Type	Disposal Sites: Containers On	Disposal Sites: Containers Off	Disposal Sites: Sludge On	Disposal Sites: Sludge Off	Contractor: Containers	Contractor: Sludge	Type of Site: Containers	Type of Site: Sludge
A-1	IV	Treatment plus municipal	NA	NA	X		NA	No	NA	On-site landfilled
A-2	IV	Direct	NA	NA	X		NA	No	NA	On-site landfilled
A-3	III	Direct	NA	NA		X	NA	No	NA	Company owned farm
A-4	I	Direct, no treatment	NA	NA	NA	NA	NA	NA	NA	NA
B-1	I	Municipal		X	NA	NA	Yes	NA	SLF	NA
B-2	I	Direct, no treatment		X		Atypical solvent	No	No	Dump	Dump
B-3	I	Direct		X	None wasted		No	NA	SLF	NA
B-4	I	Direct, no treatment		X	NA	NA	No	NA	SLF	NA
B-5	I	Municipal		X	NA	NA	No	NA	Dump	NA
B-6	I	Municipal		X	NA	NA	No	NA	Dump	NA
B-7	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-1	IV	Direct		X	X		No	No	SLF	Drying bed
D-2	IV	Direct		X	None wasted		Yes	NA	SLF, Private LF	NA
D-3	IV	Direct		X	None wasted		No	NA	Private LF	NA
D-4	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-5	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-6	I	Direct		X	None wasted		Yes	NA	SLF	NA
D-7	I	Municipal		X	NA	NA	Yes	NA	SLF	NA
D-8	IV	Direct		X	X		Yes	No	SLF	Lagoon
D-9	IV	Direct		X		X	No	No	SLF	SLF
D-10	IV	Municipal		X	NA	NA	No	NA	SLF	NA
D-11	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-12	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-13	IV	Municipal		X	NA	NA	No	NA	SLF	NA
D-14	IV	Direct		X		X	Yes	Yes	SLF	Farm

Table 4-1. Summary of Treatment/Disposal Practices at Visited Textile Plants – continued

Category/ Plant	EPA Region	Discharge Type	Disposal Sites: Containers On	Disposal Sites: Containers Off	Disposal Sites: Sludge On	Disposal Sites: Sludge Off	Contractor: Containers	Contractor: Sludge	Type of Site: Containers	Type of Site: Sludge
D-15	IV	Direct		X	X		Yes	No	SLF	Field on plant site
D-16	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
D-17	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-18	IV	Direct		X	None wasted		Yes	NA	SLF	NA
D-19	IV	Municipal		X	NA	NA	No	NA	SLF*	NA
D-20	III	Direct		X		X	Yes	Yes	SLF	Unknown
D-21	IV	Direct	No Data							
D-22	I	Direct		X	Unknown	Unknown	No	No	Dump	Unknown
E-1	IV	Municipal		X	NA	NA	No	NA	SLF	NA
E-2	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
E-3	IV	Direct		X	None wasted		Yes	NA	SLF	NA
E-4	III	Direct		X	None wasted		No	NA	SLF	NA
E-5	II	Municipal		X		Atypical	Yes	Yes	SLF*	Incineration
E-6	I	Direct, no treatment		X	NA	NA	Yes	NA	SLF	NA
E-7	IV	Municipal		X	NA	NA	No	NA	SLF	NA
E-8	IV	Municipal		X	NA	NA	Yes	NA	SLF*	NA
E-9	IV	Municipal		X	NA	NA	Yes	NA	SLF*	NA
E-10	IV	Municipal	None disposed		NA	NA	NA	NA	None disposed	NA
E-11	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
E-12	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
E-13	IV	Municipal		X	NA	NA	Yes	NA	SLF*	NA
E-14	IV	Direct		X	None wasted		Yes	NA	Private SLF*	NA
E-15	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
E-16	IV	Direct		X	None wasted		No	NA	SLF	NA
E-17	IV	Direct		X	None wasted		Yes	NA	SLF	NA
E-18	IV	Direct		X	None wasted		Yes	NA	SLF	NA
E-19	IV	Direct		X	None wasted		No	NA	SLF	NA
E-20	III	Direct		X		X	Yes	Yes	SLF*	ALF

Table 4-1. Summary of Treatment/Disposal Practices at Visited Textile Plants - continued

Category/ Plant	EPA Region	Discharge Type	Disposal Sites: Containers On	Disposal Sites: Containers Off	Disposal Sites: Sludge On	Disposal Sites: Sludge Off	Contractor: Containers	Contractor: Sludge	Type of Site: Containers	Type of Site: Sludge
F-1	IV	Municipal		X	NA	NA	No	NA	SLF	NA
F-2	IX	Municipal		X	NA	NA	Yes	NA	SLF	NA
F-3	IV	Direct		X	None wasted		Yes	NA	SLF	NA
F-4	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
F-5	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
F-6	IV	Direct		X	None wasted		No	NA	SLF	NA
F-7	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
F-8	IV	Direct		X	None wasted		Yes	NA	SLF	NA
F-9	IV	Direct		X	None wasted		No	NA	SLF	NA
F-10	IV	Direct		X	None wasted		No	NA	SLF	NA
F-11	IX	Municipal		X	NA	NA	Yes	NA	Private LF	NA
G-1	IV	Municipal		X	NA	NA	No	NA	SLF	NA
G-2	I	Municipal		X	Atypical		Yes	NA	Dump	Storing in 55-gal drums
G-3	IV	Direct		X	None wasted		Yes	NA	SLF	NA
G-4	IV	Direct	Sold		None wasted		NA	NA	NA	NA
G-5	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
G-6	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
G-7	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
G-8	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
G-9	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA
G-10	IV	Direct	Sold & washed	X	None wasted		No	NA	SLF*	NA
G-11	IV	Municipal		X	NA	NA	Yes	NA	SLF	NA

(1) Municipal - wastewater directed to municipal.
(2) Direct - wastewater discharged to surface water.
(3) NA - Not applicable because of information given earlier in table. For example, discharge of wastewater to municipal system indicates no sludge, no sludge disposal and no contractor for sludge.
(4) SLF - Sanitary landfill.
(5) ALF - Approved landfill.
(6) *Containers washed prior to disposal.

All three plants landfill the sludge; two on-site and the other off-site on farm land owned by the company. No environmental precautions are taken for the disposal of the wasted sludge.

No atypical potentially hazardous wastes were found in this industry category.

4.3.2 Category B - Wool Fabric Dyeing and Finishing

The seven plants visited in category B dispose of their dye and chemical containers with other plant trash off-site with no environmental precautions taken. Three plants use open dumps and four plants used sanitary landfills. The plants using open dumps are located in EPA Region I in a state that requires all open dumps to be converted to sanitary landfills over the next few years.

Three of the seven plants send their wastewater to municipal treatment systems. Two discharge without treatment to surface water. The remaining two have their own treatment facilities and retain sludge in unlined aeration basins. Neither of these latter plants has found it necessary to dispose of sludge because of the low solids build-up in their treatment systems.

Two of these seven plants have atypical still bottom wastes from the recovery of chlorinated organic solvents used for dry cleaning of fabric. Both plants seal this waste in drums. One sends the drums to a dump and the other uses a municipal landfill for disposal. Both disposal methods are environmentally inadequate should the drums be broken.

4.3.3 Category C - Greige Goods

There are no potentially hazardous waste streams in category C.

4.3.4 Category D - Woven Fabric Dyeing and Finishing

Twenty of twenty-one plants in category D landfill their container wastes off-site in general purpose landfills. Only one of the twenty washes their containers prior to disposal. The twenty-first plant sends their container wastes to an open dump. A twenty-second plant visited in this category refused to allow use of the waste treatment and disposal information that was obtained.

Seventeen of these twenty-two plants have their own wastewater treatment facilities and, therefore, retain sludge in aeration ponds. No lined ponds were encountered in category D. This proportion of plants with treatment systems is misleading with respect to the entire category of plants. Plants were selected to visit with an emphasis on those having in-place treatment. The estimated percentage of plants in this category not discharging to municipal treatment systems is only 32 per cent as indicated in Table 4-3 appearing later in this report.

Of the seventeen plants with treatment systems, six disposed of sludge, nine did not and no data could be obtained from two. Of the six with sludge disposal, three dispose of the sludge on-site and three off-site. On-site disposal at two plants consisted of land spreading on fields around the treatment facilities. The third plant stores their sludge in an unlined lagoon. One of the three plants using off-site disposal of sludge allows an employee to haul the sludge to his farm for use as fertilizer. A second plant uses a general purpose municipal landfill to dispose of its sludge. No disposal site information was available from the third plant.

Two instances of atypical potentially hazardous wastes were encountered in this industry category. The hazardous constituent of both were flammable hydrocarbon solvents. These wastes are presently mixed with plant trash and disposed of in a general purpose landfill.

This category of the textile industry is the one with the largest production. No evidence was found of any precautions in the disposal of potentially hazardous waste streams.

4.3.5 Category E - Knit Fabric Dyeing and Finishing

All the plants visited in category E that dispose of their container wastes, dispose of them in general purpose landfills, usually operated by municipalities or counties. Only one of the twenty plants visited did not landfill container wastes. This plant used the containers for trash barrels or allowed employees to take them home apparently for the same purpose. Six of the nineteen plants that use landfill as a disposal method wash their containers free of residual dyes and chemicals prior to disposal. This practice converts the containers into innocuous waste.

Eight plants have treatment systems and are accumulating sludge in their aeration ponds, only one of which was concrete lined. One plant discharges wtihout treatment to surface water, and eleven plants discharge to municipal treatment systems. The comment in Section 4.3.4 regarding the ratio of direct discharges to municipal dischargers applies here also. It is estimated that only 17 per cent of the plants in this category have their own treatment systems.

Two of the eight plants with treatment systems dispose of sludge. One plant stores its wasted sludge in an unlined lagoon on-site and the other dewaters its sludge to 20-25% solids and disposes of it in an approved landfill.

Two plants were found with atypical wastes. One plant generates a still bottom waste from acetone recovery and disposes of it through incineration by a hazardous waste disposal contractor. The other plant generates a still bottom waste from perchloroethylene recovery which is sent to a contractor for reclamation.

This category of the industry has demonstrated the most interest in the environmentally adequate disposal of its potentially hazardous waste streams.

4.3.6 Category F - Carpet Dyeing and Finishing

All eleven plants visited in category F dispose of their dye and chemical container wastes off-site in general purpose landfills. None of the plants cleaned the containers prior to disposal.

Five of these plants have treatment systems and are accumulating and retaining sludge in their aeration basins, which are all unlined. Only one plant disposes of sludge, which is a very small amount to an on-site sludge drying bed.

Three of the eleven plants have an atypical potentially hazardous waste consisting of lint that is wet with non-fixed dye solution. All three landfill this waste with plant trash.

4.3.7 Category G - Yarn and Stock Dyeing and Finishing

Nine of the eleven category G plants visited dispose of their dye and chemical container wastes in general purpose landfills. One plant sends container wastes to an open dump and another sells the containers. Only one plant washes the containers prior to disposal.

Three plants were found to have treatment systems and are accumulating sludge in unlined aeration basins. There is no sludge disposal in this category because of very slow solids build-up in the treatment systems.

One of these eleven plants has an atypical potentially hazardous waste stream consisting of flammable solvent and resin slurries from yarn finishing operations. This waste is sealed in drums and stored on the plant site awaiting a decision on disposal.

4.4 Comparison of On-Site Vs. Off-Site Treatment and Disposal

4.4.1 Container Wastes

All the plants visited that dispose of container wastes use off-site disposal. The following is a summary of the proportions of use of contractors for container waste disposal:

Industry Category	Percentage of Plants: Contractor Disposal	Percentage of Plants: Plant Disposal
A - Wool Scouring	— no container wastes —	
B - Wool Fabric D and F	29	71
D - Woven Fabric D and F	67	33
E - Knit Fabric D and F	74	26
F — Carpet D and F	64	36
G - Yarn and Stock D and F	80	20

The disposal sites are all local, usually within 16 kilometers (10 miles) of the plant.

4.4.2 Sludge Wastes

Plants with wastewater treatment systems all retain some sludge in their treatment ponds. Disposal of sludge is necessary only when the solids level in the wastewater treatment system builds to a point where the efficiency of the biological system would be affected. The following is a summary of those plants which were visited that dispose of sludge:

Category	Percentage of Plants With Treatment That Waste Sludge	Percentage of Plants Wasting On-Site	Percentage of Plants Wasting Off-Site	Percentage of Plants Using Contractors
A	100	67	33	0
B	0	NA	NA	NA
D	41	50	50	33
E	0	NA	NA	NA
F	0	NA	NA	NA
G	0	NA	NA	NA

Off-site disposal of sludge is local, usually within 16 kilometers (10 miles) of the plant. Some of the plants that presently use on-site disposal of wasted sludge would prefer to dispose of the sludges off-site in sanitary landfills and are currently seeking permission from local authorities to do so.

4.4.3 Atypical Wastes

Off-site disposal of the atypical wastes of these industries was the practice at all plants studied except one. There the waste is stored in metal drums on-site awaiting permission from local authorities for disposal at the local municipal landfill.

4.5 Safeguards Employed by the Textile Industry

In general, the textile industry handles dye and chemical contaminated containers and wastewater treatment sludges as non-hazardous materials. Most plants combine these containers with trash in landfills. A few wash or clean the containers prior to disposal, reuse, sale, or return. The others leave a small amount of residual dyes and chemicals clinging to the surfaces of the disposed containers. Wastewater treatment sludges are usually land disposed without any environmental safeguards. Only one plant was found to dispose of dewatered sludge in an approved landfill. Several retain their sludges in concrete lined basins.

4.6 Hazardous Waste Management by Private Contractors

Many plants dispose of process and wastewater treatment wastes by contractors. Generally these contractors haul wastes to a disposal site where one or more of the disposal practices discussed previously is carried out. A list of these contractors appears as Appendix B.

Three types of services are performed by different contractors:

(1) Haulers who perform no function other than transporting the wastes to the nearest public landfill. These contractors are normally the ones that handle trash including dye and chemical containers.

(2) Private landfill disposal by operators who may also do the hauling. The wastes that these operators will accept varies depending on the location and nature of their disposal area. This includes "unlicensed" contractors who remove sludge and spread it on their own land as a fertilizer.

(3) Hazardous waste contractors disposal. These contractors accept, treat, and dispose of hazardous materials as a major portion of their business and are equipped to handle them. Hazardous waste contractors presently are rarely used by the textile industry except for solvent-containing wastes.

Private contractors handling dye and chemical containers mixed with trash take no environmental precautions.

Sludge is sometimes disposed of by private contractors and, when it is, environmental precautions are usually minimal. Landfilling, land dumping, and land spreading are used in the same manner as by textile plants. One notable exception was found where dewatered sludge was disposed of in an approved landfill.

In a number of cases the waste solvents and solvent sludges are handled in an environmentally adequate fashion by reclaiming and incineration.

4.7 Treatment and Disposal Technologies for Potentially Hazardous Waste Streams by Industry Category *

For purpose of presenting potentially hazardous land-destined textile wastes and their levels of treatment and disposal in an orderly fashion, three categories of wastes are considered:

- Containers with residual dyes and chemicals,
- Wastewater treatment sludges,
- Other atypical, potentially hazardous wastes.

* The reader is cautioned that no waste products from the textiles industry have been demonstrated to be hazardous by this study. EPA reserves its judgments pending a specific legislative mandate.

The container wastes and wastewater treatment sludges are both common to most of the industry and, to avoid needless repetition, their treatment and disposal technologies are presented on an overall industry basis. The atypical wastes are covered individually, identified as to origin and specific comments made as to pertinent technology. The three technology levels are defined as follows:

Level I - Technology currently employed by typical facilities; i.e., broad average present treatment and disposal practice.

Level II - Best technology currently employed. Identified technology at this level must represent the soundest process, from an environmental and health standpoint, currently in use in at least one location.

Level III - Technology necessary to provide adequate health and environmental protection. Identified technology may include pilot or bench scale processes provided the exact stage of development is identified. Level III technology as defined in this report represents contractor judgment, and not that of the EPA. This level of technology as defined for a particular potentially hazardous waste stream is merely an attempt by the contractor to define an environmentally acceptable technology. Thus, the technology level defined should not be interpreted as a basis for future regulations. It is not basis for future regulations. It is not based on cost-benefit, economic, or other analysis required to appropriately define Level III technology.

The levels of technology determined for the potentially hazardous land-destined waste streams in this industry are presented in Tables 4-2 and 4-3. Table 4-2 deals with dye and chemical containers with residual contamination and Table 4-3 deals with wastewater treatment sludges. Table 4-4 summarizes the other atypical, potentially hazardous waste streams and their treatment and disposal. Figures 4-1, 4-2 and 4-3 illustrate the three levels of technology for the treatment and disposal of potentially hazardous land-destined wastes in the textiles industry.

4.7.1 Dye and Chemical Container Wastes

Category A (wool scouring) generates no dye and chemical container wastes. All other textile industry plants that dye and finish their products have container wastes. Most of these facilities dispose of these containers with their small amounts of residual dyes and chemicals in sanitary landfills. This constitutes Level I technology. Levels II and III technologies are similar with the exception of washing and cleaning the containers prior to disposal. This practice adds a small amount of raw waste to the wastewater going to treatment, but transforms a potentially hazardous land-destined waste stream to innocuous trash.

Table 4-2. Levels of Technology for the Dye and Chemical Container Waste Streams

Factor	Level I	Level II	Level III
Treatment/Disposal Technology	Landfilling	Washing and cleaning of containers prior to disposal	Same as Level II
Estimate of Number and (Percentage) of Plants Now Using Technology	Category: Technology Landfilling B 64 (57) D 620 (95) E 480 (65) F 144 (100) G 252 (73)	Category: Technology Wash & Clean B 0 (0) D 33 (5) E 220 (30) F 0 (0) G 31 (9)	Same as Level II
Present Adequacy of Technology	Disposal practices environmentally inadequate	Environmentally adequate	Same as Level II
Future Adequacy of Technology	Environmentally inadequate	Environmentally adequate	Same as Level II
Description of Residual Potentially Hazardous Wastes (kg/kkg of production)	Category: Dyes: Container, Dyestuff; Chemicals: Container, Chemical B 1.3 0.006 1.6 0.02 D 0.47 0.0023 0.77 0.04 E 0.9 0.0023 0.92 0.0015 F 0.13 0.0007 0.18 0.0008 G 0.87 0.002 2.2 0.02	No potentially hazardous wastes	Same as Level II
Physical and Chemical Properties	Containers have residual solid and liquid dyestuffs and chemicals clinging to their surfaces	Containers are clean - there are no remaining residues	Same as Level II

Table 4-2. Levels of Technology for the Dye and Chemical Container Waste Streams - continued

Factor	Level I	Level II	Level III
Factors Affecting Hazardousness	(1) Composition and amount of potentially hazardous dyes and chemicals used in plant. (2) Ambient conditions for landfills- pH level, leachate character, soil permeability	None	Same as Level II
Reliability of Technology	Technology not reliable for maintaining environmental safeguards	Reliable	Same as Level II
Limitation of Technology	Allows potentially hazardous residual dyes and chemicals to be landfilled	None	Same as Level II
Problems and Comments	Container residues are presently handled as non-hazardous materials	Simple washing and cleaning of containers transforms potentially hazardous waste into environmentally safe innocuous waste	Same as Level II
Compatibility with Existing Facilities	Disposal facilities already exist	No new facilities needed	Same as Level II
Non-Land Environmental Impact	Possible ground and surface water contamination	Will slightly increase raw waste load to water treatment system	Same as Level II
Energy Requirements	Slight - containers represent only a small portion of landfilled trash	None	Same as Level II

Table 4-2. Levels of Technology for the Dye and Chemical Container Waste Streams - continued

Factor	Level I	Level II	Level III
Monitoring and Surveillance Techniques	None employed	Visual check of containers prior to disposal	Same as Level II
Installation Time for New Facilities	None needed	None needed	Same as Level II

Table 4-3. Levels of Technology for the Wastewater Treatment Sludges

Factor	Level I	Level II	Level III
Treatment/Disposal Technologies	(1) Retention of sludge in treatment ponds (2) General land disposal of wasted sludge	(1) Retention of sludge in lined treatment ponds (2) Disposal of wasted sludge in approved landfill	(1) Same as Level II (2) Same as Level II (3) Incineration plus ash disposal in approved landfill (alternate method for technology 2)
Estimated Number and (Percentage) of Plants Now Using Technology	Category: Technology — Retention of Sludge / Land Disposal of Wasted Sludge A 8 (50) 8 (100) B 39 (35) 0 (0) D 208 (32) 86 (41) E 125 (17) 0 (0) F 43 (30) 0 (0) G 65 (19) 0 (0)	Category: Technology — Lined-Pond Retention of Sludge / Approved Landfill Disposal of Wasted Sludge A 5 (67) 0 (0) B 0 (0) 0 (0) D 0 (0) 0 (0) E 15 (12) 15 (12) F 0 (0) 0 (0) G 0 (0) 0 (0)	(1) Same as Level II (2) Same as Level II (3) Incineration plus disposal of ash in approved landfill - 0 plants (0%) all categories
Present Adequacy of Technologies	Retention and disposal practices are environmentally inadequate	Retention of sludge in lined ponds and approved landfilling are environmentally adequate.	(1) Same as Level II (2) Same as Level II (3) Incineration will require adequate containment of air pollutants plus safe disposal of ash.
Future Adequacy of Technologies	Adequacy of practices will not be improved as wastewater treatment BPTCA and BATEA technologies are required and sludge volumes increase	Will depend on the type and effectiveness of the pond lining. Approved landfilling will be environmentally adequate.	(1) Same as Level II (2) Same as Level II (3) Incineration will require adequate containment of air pollutants plus safe disposal of ash.

Table 4-3. Levels of Technology for the Wastewater Treatment Sludges - continued

Factor	Level I	Level II	Level III
Description of Residual Potentially Hazardous Wastes	(1) Retained sludge in kilograms/typical plant Category: Dry Wet A 780 7800 B 1.6 20,000 D 67 7300 E 400 60,000 F 5.2 22,000 G 2.9 20,000 (2) Wasted sludge in kg/kkg of product Category: Dry Wet A 570 5700 B 0 0 D 20 2300 E 0 0 F 0 0 G 0 0	(1) Same as Level I (2) Same as Level I Except that wasted sludge would have a higher solids content depending on the degree of dewatering before approved landfilling.	(1) Same as Level I (2) Same as Level I (3) Incinerator ash weights will vary with content of original sludge
Physical and Chemical Properties	(1) Retained sludges range in solids content from <1% to 10% depending on the industry category. (2) Wasted sludges range in solids content from 2% to 10% depending on the industry category and the method of sludge disposal used. Land spraying with irrigation-type equipment requires low solids content. Land spreading and landfilling of solids requires high solids content. Also, depending on the wastewater treatment involved, these solids may be mostly organic (activated sludge with residual dyes, heavy metals and chemicals) or mixtures of these organics with inorganics such as limes, alum, and iron compounds.	(1) Same as Level I (2) Approved landfilling normally requires sludge dewatering prior to disposal. Solids after dewatering range from 10 to 25 percent.	(1) Same as Level I (2) Same as Level II (3) Incineration will normally require sludge dewatering. Ash from incineration will contain primarily inorganic chemicals including potentially hazardous heavy metals.

Table 4-3. Levels of Technology for the Wastewater Treatment Sludges - continued

Factor	Level I	Level II	Level III
Factors Affecting Hazardousness	(1) Permeability of soil under retention ponds (2) Composition and amount of potentially hazardous dyes and chemicals used in plant Ambient conditions for land spreading or landfilling - pH level, permeability of soil around landfills, and proximity of surface and ground water	(1) Integrity of pond liners; i.e., cracking of concrete liners or chemical attack on plastic liners (2) Proper management of approved landfill	(1) Same as Level II (2) Same as Level II (3) Incineration concentrates any potentially hazardous inorganic component of original sludges. Proper management of approved landfill.
Reliability of Technologies	Present technologies not reliable for environmentally adequate disposal.	Good. Technologies are widely used and demonstrated in this and other industries.	Same as Level II
Limitation of Technologies	(1) Sludge retention in unlined ponds can possibly result in percolation to ground water supplies (2) Land disposal of potentially hazardous sludge by landfilling or land spreading in uncontrolled facilities can lead to leachate and runoff problems.	(1) Same approved pond liners may be chemically attacked or inadvertantly torn or cracked (2) Approved landfill liners may also deteriorate	(1) Same as Level II (2) Same as Level II (3) Incineration — none.
Problems and Comments	Sludges are now considered by the industry to be non-hazardous materials. Additional work needs to be done to establish: (a) the effect of an aerobic decomposition of dyestuffs (b) the environmental impact of land spreading and landfilling of potentially hazardous sludges from the textile industry	(1) Costs to line aeration basins will be high (2) There are very few approved landfills where most of the textile industry is located	(1) Same as Level II (2) Same as Level II (3) The costs of environmentally adequate incineration equipment are high. Fuel costs are high and some fuels are not available. Contract incineration may not be available to textile plants.

Table 4-3. Levels of Technology for the Wastewater Treatment Sludges - continued

Factor	Level I	Level II	Level III
Compatibility with Existing Facilities	Retention and disposal facilities already exist	(1) Can line existing pond if necessary (2) Good. Sludge dewatering is an add-on. Approved landfills are separate installations.	(1) Same as Level II (2) Same as Level II (3) Contract incinerators are separate installations. On-site incineration is an add-on.
Non-Land Environmental Impact	Possible ground and surface water contamination	None, provided adequate safeguards are taken with pond liners and approved landfills	(1) Same as Level II (2) Same as Level II (3) Air wastes from incineration. None with environmentally adequate incinerator.
Energy Requirements	(1) None (2) Slight - pumping, handling and hauling of land disposed sludges	(1) None (2) Slight - handling and hauling of land-filled sludges	(1) None (2) Same as Level II (3) Incineration - large fuel requirements
Monitoring and Surveillance Techniques	None employed	Surface and ground water monitoring for leachate.	(1) Same as Level II (2) Same as Level II (3) Incineration - air pollution monitoring required
Installation Time for New Facilities	No new facilities required	Pond liner - 6 months Sludge dewatering - 12 months Approved landfill - 12 months	Same as Level II, incineration - 12 months

Table 4-4. Atypical Potentially Hazardous Textile Industry Wastes

Subcategory	Waste Description	Quantity (Dry) (kg/kkg of Product)	No. of Plants (% of Plants)	Potential Hazards Involved	Comments on Treatment/Disposal Technology
A	No atypical wastes	-	-	-	-
B	Still bottoms from recovery of dry-cleaning chlorinated solvents	5	2 of 7 plants visited (28%)	Air pollution, ground water contamination	Presently sealed in drums and sent to landfills or land dumps. Future environmentally adequate treatment/disposal can be by reclaiming or incineration.
D	Hydrocarbon solvents and sludges	50	1 of 22 plants visited (4.5%)	Air pollution, fires	Presently landfilled. Future environmentally adequate treatment/disposal can be by reclaiming or incineration.
D	Finishing sludges containing adhesives, silicones, and solvents	333	1 of 22 plants visited (4.5%)	Air pollution, fires	Presently landfilled. Future environmentally adequate treatment/disposal can be by reclaiming or incineration.
E	Acetone recovery still bottoms	63	1 of 20 plants visited (5%)	Air pollution, fires	Presently incinerated by hazardous waste disposal contractor-environmentally adequate.
E	Perchloroethylene still bottoms	10	1 of 20 plants visited (5%)	Air pollution, ground water contamination	Reclaimed by contractor at no cost to plant - environmentally adequate

Table 4-4. Atypical Potentially Hazardous Textile Industry Wastes – continued

Subcategory	Waste Description	Quantity (kg/kkg of Product)	No. of Plants (% of Plants)	Potential Hazards Involved	Comments on Treatment/Disposal Technology
F	Lint wet with non-fixed dye	12 (20 wet)	3 of 11 plants visited (27%)	Pollution of surface and ground water	Presently landfilled with trash. Future environmentally adequate treatment/disposal technologies include washing, approved landfilling, or incineration.
G	Solvent and resin slurries from yarn finishing operations	0.09	1 of 11 plants visited (9%)	Air pollution, fires	Presently sealed in drums and stored on-site. Future environmentally adequate treatment/disposal options include reclaiming, approved landfilling or incineration.

Figure 4-1. TYPICAL MODEL OF LEVEL I TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY

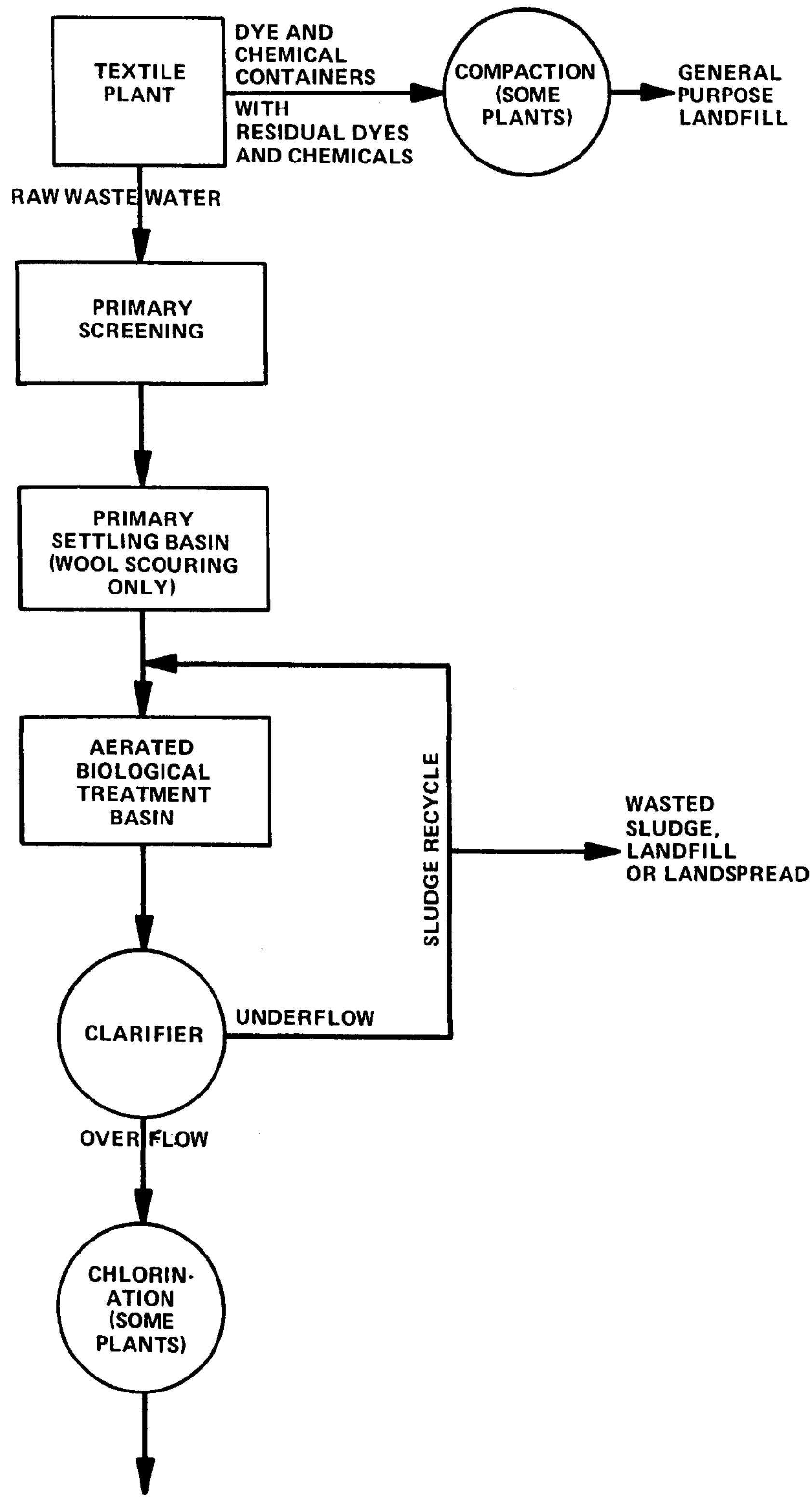


Figure 4-2. TYPICAL MODEL OF LEVEL II TECHNOLOGY FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY

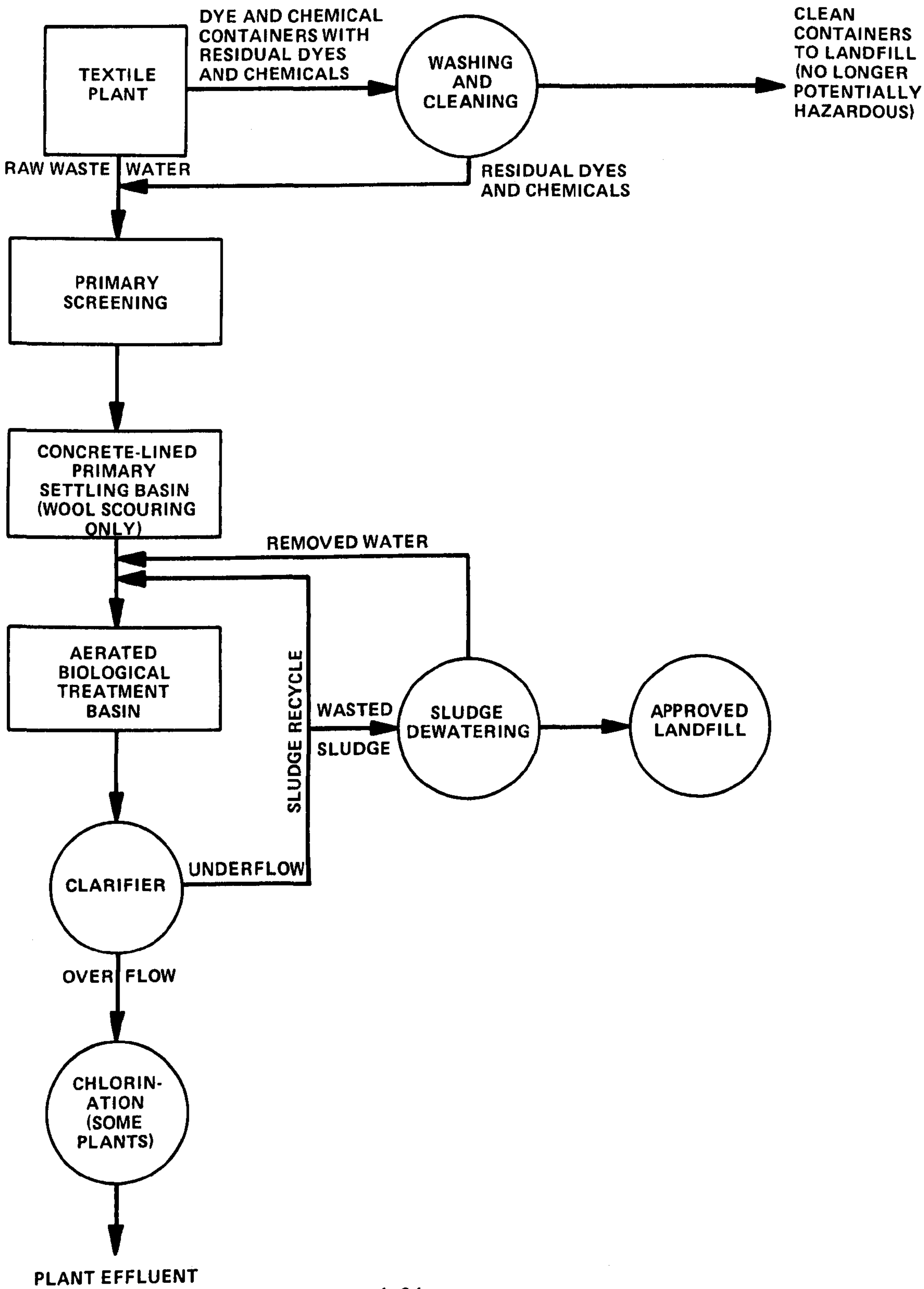
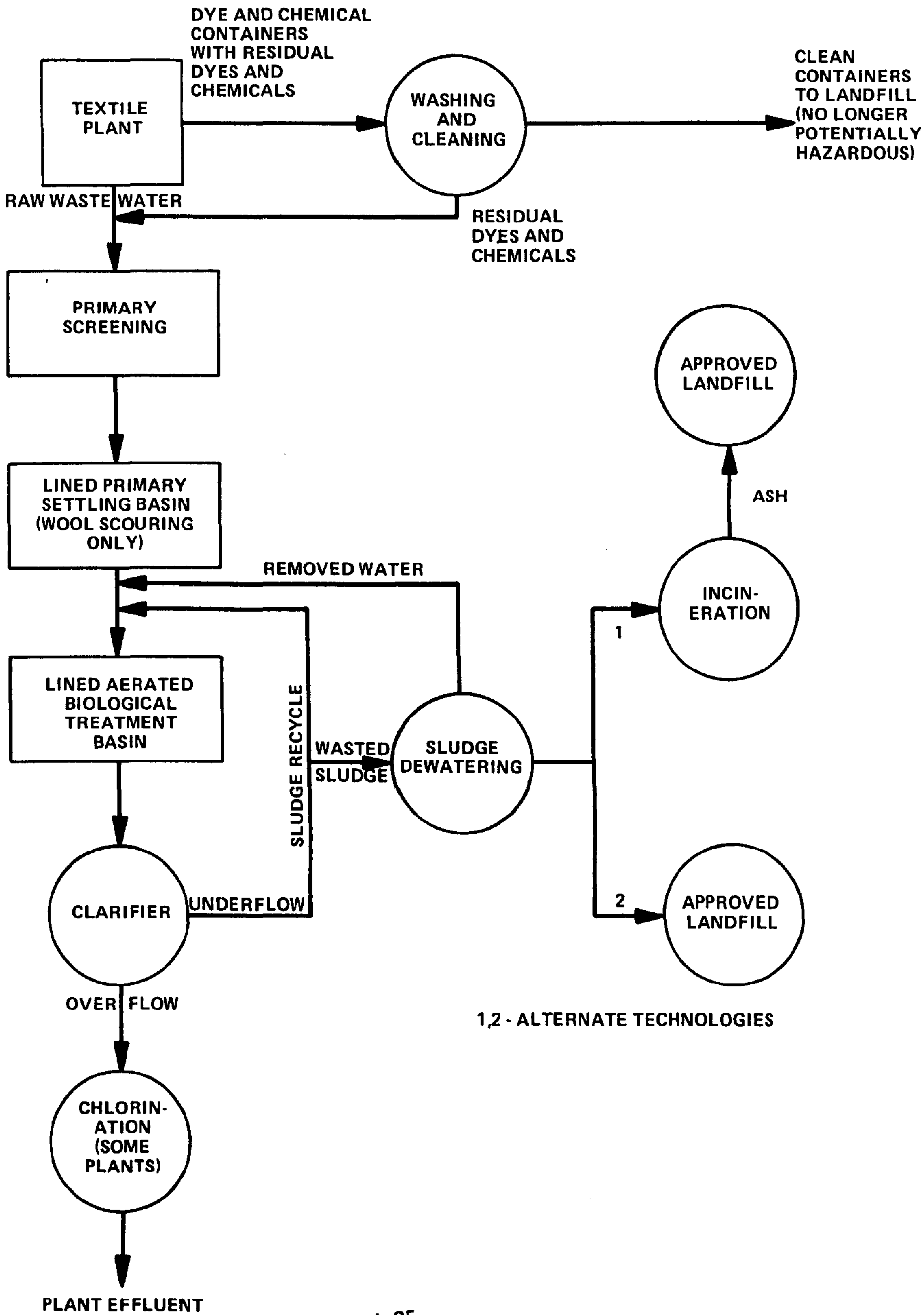


Figure 4-3. TYPICAL MODEL OF LEVEL III TECHNOLOGIES FOR POTENTIALLY HAZARDOUS WASTE STREAMS IN THE TEXTILES INDUSTRY



The percentages of plants shown in Table 4-2 using the Levels I, II and III technologies were estimated from the plant visit data. The number of industry-wide plants using the technologies were derived by applying these percentages to the total number of facilities in each industry category.

Because dye and chemical containers can be decontaminated by washing, there is no need for hazardous waste disposal technology. Only good waste control practices are required prior to disposal of containers.

4.7.2 Wastewater Treatment Sludges

The data on treatment and disposal of wastewater treatment sludges are summarized in Table 4-3. There are two ways that sludges generated in textile dyeing and finishing plant wastewater treatment facilities can pose a hazard to the environment. One is through landfilling, land spreading or land dumping of wasted sludge with potentially hazardous constituents in places with no controls on leachate or runoff. The other way is through use of an unlined, non-impervious aeration basin where the sludge is being generated and retained until removal becomes necessary.

Level I technologies for the handling and disposal of this sludge consists of the retention of sludge in unlined aeration basins and the disposal of wasted sludge in general purpose landfills or dumps or land spreading on farmland.

Level II technologies were found to be the use of lined aeration basins to prevent the percolation of retained sludge and the disposal of dewatered sludge in an approved landfill.

Level II technologies are also Level III. Additional Level III technology is the incineration of dewatered sludge and approved landfilling of the residual ash. Incineration by a contractor would probably be selected by the industry over installation of on-site incinerators because of the high cost of environmentally adequate incinerators.

Of course, sludges are generated in only those facilities having their own wastewater treatment systems. The percentages listed of those plants in each industry category that retain sludges were obtained from reference 10. These correspond to the per cent of each industry segment with treatment systems. The number of plants in each category that retain sludge was obtained by applying these percentages to the total number of facilities in each category.

The percentage of plants with treatment systems that dispose of sludge was determined from the plant visit data. The industry-wide number of plants wasting sludge was obtained by applying these percentages to the total number of plants in each category that retain sludge (have treatment systems).

BPCTCA and BATEA stand for "best practicable technology currently available" and "best available technology economically achievable" which are used with reference to the wastewater treatment technologies and effluent standards to be achieved by 1977 and 1983, respectively.

4.7.3 Discussion of the Atypical Potentially Hazardous Wastes

The information on atypical potentially hazardous wastes is summarized in Table 4-4. Most of these wastes are organic solvents. Unlike the container and water treatment sludge wastes which are potentially hazardous from a toxicity standpoint, these atypical wastes are potentially hazardous primarily because of flammability. These wastes are sometimes recognized by the textile industry as potentially hazardous and are disposed of by environmentally adequate means such as reclaiming or incineration.

Other atypical wastes such as lint containing excess dye are currently being landfilled, but can be treated and disposed of in environmentally adequate fashion by washing, approved landfilling or incineration.

4.7.4 Other Treatment and Disposal Technology Options

4.7.4.1 Specialized Approved Landfills

General purpose approved landfills accept a wide variety of waste materials. These may be either a public facility or privately-owned. Another type of approved landfill is one designed and used by an individual plant or company for only their wastes. Normally such facilities are installed only when the waste volume is large or there is sufficient hazard for the company to want to retain ultimate control of waste material. These landfill areas have all the characteristics described for general purpose approved landfills --- impermeable barriers, monitoring, and leachate control and treatment. They present a number of advantages over general purpose landfills:

- handling and hauling charges are minimized;
- interactions with other wastes can be controlled or eliminated; and
- control of ultimate treatment/disposal conditions is maintained.

Some textile plants have sufficient wastewater treatment sludge to warrant specialized approved landfill disposal, that is, disposal in a landfill that handles only such material. However, this has not been found in use in the textile industry.

4.7.4.2 Ocean Disposal

At least one textile company is known to have in the past used ocean disposal for its wastewater treatment sludges. Presently, there is no known ocean disposal practiced in the industry.

4.7.4.3 Chemical Fixation of Wastes

There are a number of processes for converting potentially hazardous sludges into relatively innocuous solid materials by chemical fixation. These processes involve reaction of cements, lime, mortars, plaster-of-paris, and silicates and other readily available low-cost inorganic chemicals with sludge to produce a solid material with reduced leachability of metals and other components such as oil and organics. The degree of "fixation" depends on the chemicals used and the nature of the sludge. The applicability of this treatment technology to textile sludges has not been demonstrated.

4.7.4.4 Encapsulation of Wastes

Land-destined hazardous wastes may be physically encapsulated in impervious materials such as concrete, asphalt or plastics prior to disposal. This technique is normally reserved for relatively small volumes of very hazardous materials and is not a practical application for the potentially hazardous wastes of the textiles industry.

5.0 COST ANALYSIS

5.1 Introduction

Although the types of wastes and the waste treatment and disposal technologies for most textile industry categories are similar, the amounts of wastes differ from category to category. Costs of treatment and disposal are determined by both the treatment and disposal technology used and the amount of waste involved. Other factors influencing disposal costs are the use of municipal sewage treatment systems and the indefinite retention of sludges in the plant treatment system ponds. Sending the wastewater to a municipal system, for example, not only transfers the generation and disposal of the potentially hazardous sludges to the municipality, it also transfers the sludge disposal costs as well. Retention of sludge in a plant's wastewater treatment system may continue for 5 to 10 years or even longer without the need of removal for disposal. Sludge disposal costs are zero during this period. If and when some sludge has to be disposed of, costs are then incurred. These and other factors which significantly influence costs are discussed as they apply in the individual industry category cost analysis sections.

5.2 Techniques and Assumptions Used

5.2.1 Sources of Cost Information

Cost information contained in this report was assembled directly from industry, from waste treatment and disposal contractors, engineering firms, equipment suppliers, government sources, and published literature. Whenever possible, costs are based on actual installations, engineering estimates for projected facilities as supplied by contributing companies, or from waste treatment and disposal contractors' quoted prices. In the absence of such information, costs estimates were developed insofar as possible from plant-supplied costs for similar waste treatments and disposal for other plants or industries.

Cross-checks were also made, whenever information was available, for treatment and disposal costs from different sources, such as contract disposal companies.

5.2.2 Cost References and Rationale

5.2.2.1 Interest Costs and Equity Financing Charges

Capital investments involve the expenditure of money which must be financed either on borrowed money or from internal equity. Estimates for this study were based on 10 per cent cost of capital, representing a composite number for interest paid or return on investment required. This value was established as reasonable by discussions with industry.

5.2.2.2 Time Index for Costs

All cost estimates are based on current prices and when necessary were adjusted to this basis using the chemical engineering plant cost index. The inflationary nature of the past years makes it particularly important that this 1975 constant dollar basis be cited for any cost estimation purposes. If desired, current costs may be converted to December 1973 values (used in similar studies on different industries in the past) by multiplying by a factor of 0.82.

5.2.2.3 Useful Service Life

The useful service life of treatment and disposal equipment varies depending on the nature of the equipment and process involved, its usage pattern, maintenance care and numerous other factors. Individual companies have their own service life values based on actual experience and use these values for internal amortization. A second source of such information, based on other factors less relevant than company experience, is Internal Revenue Service guidelines.

Based on discussions with industry and condensed IRS guideline information, the following useful service life values were used:

Item	Estimated Useful Service Life, Yrs.
(1) General Process Equipment	10
(2) Incineration, Distilling and Retorting Equipment	5
(3) Ponds, Lined and Unlined	20
(4) Trucks, Bulldozers, Loaders and other such materials handling and transporting equipment	5

5.2.2.4 Capital Costs

Capital costs are defined, for the purposes of this report, as all front-end loaded, out-of-pocket expenditures for the provision of facilities. These costs include equipment, construction and installation, buildings, services, engineering, special start-up costs and contractor profits and contingencies.

When capital costs are known for a specific plant using a given treatment and disposal technology, cost adjustment to the typical plant size was made using exponential factors of size. The cost of process equipment is scaled by an exponent of 0.6 and costs for treatment or disposal ponds by an exponent of 1.0. This latter exponent was applied to any capital item for which no appreciable economy of scale is appropriate.

5.2.2.5 Annualized Capital Costs

Almost all capital costs for treatment and disposal facilities are front-end loaded; i.e., most if not all of the money is spent during the first year or two of the useful life. This present worth sum can be converted to equivalent uniform annual disbursements by utilizing the Capital Recovery Factor Method:

$$\text{Uniform Annual Disbursement} = P \frac{i\ (1+i)\ \text{nth power}}{(1+i)\text{nth power} - 1}$$

Where P = present value (capital expenditure)
i = interest rate, %/100,n = useful life in years

The capital recovery factor method is used for all annualized capital costs in this report, which, in effect, would be similar to constant annual payments on principal and interest where capital facilities are paid for through a constant payment mortgage.

5.2.2.6 Treatment of Land Costs

Land-destined hazardous wastes require removal of land from other economic use. The amount of land so tied up will depend on the treatment/disposal method employed and the amount of wastes involved. Although land is non-depreciable according to IRS regulations, there are numerous instances where the market value of the land for land-destined wastes has been significantly and permanently reduced, or actually become unsuitable for future use due to the nature of the stored waste. Therefore, where necessary, costs estimates have assumed land values and capital recovery on the following basis:

(1) If land requirements for on-site treatment and disposal are not significant, then no cost allowance was made.

(2) Where on-site land requirements are significant and the storage or disposal of wastes does not affect the ultimate market value of the land, cost estimates include only interest on invested money.

(3) For significant on-site land requirements where the ultimate market value and/or availability of the land was seriously reduced, cost estimates include both capital depreciation and interest on invested money.

(4) Off-site treatment and disposal land requirements and costs for contractors are not considered directly. It is assumed that land costs are included in the contractor's fees along with other expenses and profit.

In view of the extreme variability in land costs, no attempt was made to set different land values for each plant, industry or location. Instead, a value of $2,500/hectare ($1,000/acre) was assumed.

5.2.2.7 Operating Expenses

Annual costs of operating the treatment and disposal facilities include labor, supervision, materials, maintenance, taxes, and insurance. The operating costs combined with annualized capital costs give the total annual costs for treatment and disposal operations.

a. Labor and Supervision Costs

Based on discussion with textile industry plant management personnel, the following labor costs were used:

Category	$/hour
Process operators, plant laborers --	5.00
Truck driver, equipment operators --	5.00
Supervision --	7.50

The above figures include fringe benefits and plant overhead.

b. Taxes and Insurance

Taxes and insurance were taken as 3 percent of invested capital.

c. Other Operating Costs

Operating costs for maintenance, materials, power and energy are variable for each individual case.

5.2.2.8 Rationale for "Typical Plants"

All plant costs are estimated for "typical plants" rather than for any actual plant. "Typical plants" are defined for the purpose of these cost estimates as:

For dye and chemical container wastes -- The arithmetic average of production size for all plants in the specific industry category.

For wastewater treatment sludge wastes -- The arithmetic average of production size for those plants in each industry category discharging wastes to surface water. These figures were obtained by multiplying the total category production by 0.65 (the ATMI estimates that plants comprising 65% of industry production discharge to municipal systems) and then dividing by the total number of plants in the category having discharge to waterways as determined from reference 10.

The vast majority of textile plants are located in the East, so this description was used throughout the report whenever typical location is mentioned. Textile plant processing equipment age has little significance as far as treatment and disposal technology and the associated costs are concerned, and was not considered a factor in describing "typical plants".

It should be noted that the per ton costs to treat and dispose of potentially hazardous wastes at any one given plant may be considerably higher or lower than the typical plant because of individual circumstances.

5.2.2.9 Definition of Technology Levels

Costs were developed for the three levels of technology which are repeated here:

Level I

Technology currently employed by typical facilities, i.e., broad coverage present treatment and disposal practice in the industry category.

Level II

Best technology currently employed. Identified technology at this level must represent the soundest process from an environmental and health standpoint, currently in use in at least one location in the industry category. Installations must be commercial scale; pilot plant and bench scale installations are not suitable.

Level III

Technology necessary to provide adequate health and environmental protection. Level III may be more or less sophisticated or may be identical with Level I or II Technology. At this level, identified technology may include pilot or bench scale processes providing the exact stage of development is identified. One pertinent difference between Level III Technology and Levels I and II Technology is that it is not necessary for any plant in the industry category to be using Level III Technology. Technology transfers from other industries are also included. The definition of Level III Technology as defined in this report represents contractor judgment, and not that of the EPA. This level of technology as defined for a particular potentially hazardous waste stream is merely an attempt by the contractor to define an environmentally acceptable technology. Thus, the technology level defined should not be interpreted as a basis for future regulations. It is not based on cost-benefit, economic, or other analyses required to appropriately define Level III Technology.

5.3 General Cost Basis for Treatment and Disposal Technologies

5.3.1 Waste Control Technology Cost Basis

Potentially hazardous dye and chemical residues are removed from containers by washing at a number of plants. This decontamination procedure makes the containers innocuous, after which they can be disposed of as trash, reused, returned or sold. Costs for washing and cleaning are small because of the use of existing plant personnel. It is estimated that the annual costs for a typical plant in each category would be $250 (one man-hour per week for 50 weeks).

5.3.2 Storage or Retention Lagoons Cost Basis

A typical plant in the textiles industry that has its own wastewater treatment system will retain sludge in the aeration lagoon and dispose of the excess as required. All plants with water treatment facilities will retain some quantity of sludge but only the wool scouring and woven fabric dyeing and finishing categories (A and D) typically waste sludge. Almost all of the aeration lagoons in the textiles industry are unlined. Lining with plastic sheet, clay or concrete to prevent leachate from reaching ground water is a demonstrated technology in this and other industries.

Estimates of installed costs for various types of pond liners follow:

Liner Material	Additional Cost, $/sq.m.
thin clay liner (<2 in.)	$2.50
sprayed asphalt	$2.50
20 mil PVC	$3.70
30 mil Hypalon	$7.40
concrete	$10.00
thick clay liner (2 ft.)	$10.00

Two typical pond sizes were found in the textiles industry, 0.38 and 0.89 hectare, which correspond to 0.9 and 2.0 acres. The smaller size is applicable to industry categories A, D, E, and F while the larger size applies to categories B and G. The following estimates were made for the costs involved in cleaning and preparing the typical sized ponds for installation of liners:

	Pond Size	
	0.38 ha.	0.89 ha.
Cleaning of existing pond (@ $10/m^3 of removed sludge)	$18,750	$44,500
Earthwork on existing pond (@ $1/m^3 of earth moving)	1,250	3,000
Totals	$20,000	$47,500

Pond costs were attributable to wastewater treatment costs and therefore no cost is attributed to the retention of sludge in existing unlined ponds.

5.3.3 Land Dumping Cost Basis

Land dumping costs are almost the same as landfilling costs. Normally, most of the cost is for handling and hauling. Analysis of the collected plant data for off-site disposal of such solid wastes as trash and dye and chemical containers, shows an average of about $13/kkg for hauling and disposal. Disposal costs for the individual plants range from $2 to $50 per kkg of trash disposed. The high average cost per kkg of this type of waste is due to low bulk density (one metric ton may occupy several cubic meters of volume). Contractors charge on a volume and trip basis.

Land dumping of sludges has quite different costs than those for container waste. Hauling costs are estimated to be approximately $2/kkg of wet solids for the short (0-20 kilometers) hauling distances involved. Therefore, the land dumping cost for sludges is highly dependent on the solids content when it is disposed of. Dewatering of sludge becomes an attractive option to minimize the hauling costs.

5.3.4 Land Spreading Cost Basis

Costs for land spraying of 5 percent solids liquid sludge, based on information from one plant, has been estimated as $25/kkg of dry solids. This value is highly sensitive to the solids level of the sludge and the percent of the time that the system is actually in use. Both of these factors may be expected to vary widely from plant-to-plant.

Costs for land spreading of 20 percent solids dewatered sludge are greater than for simple land dumping because of the spreading equipment involved and is estimated as $20/kkg of dry solids handled.

5.3.5 Cost Basis of General Purpose Landfilling

The $13/kkg cost given for land dumping was developed from information collected on landfilling operations. Most of the plants employ contractors who pick up the trash and containers, either compacted or uncompacted, and take them to a local public landfill. Although some public landfills charge a significant fee (up to $7/kkg), most of them are either free or charge a fee on the order of $1-2/kkg for landfilling operations (reference 32). Our estimate of the average landfilling cost is $15/kkg.

For wastewater treatment sludges, the average landfilling cost is estimated to be $4/kkg of wet sludge ($2/kkg dumping cost plus $2/kkg landfill cost).

5.3.6 Cost Basis for General Purpose Approved Landfills

Operators of approved general purpose landfills charge fees of \$3 to \$7 per metric ton (reference 32). Therefore the cost for dye and chemical containers including the \$13/kkg local hauling costs would be as high as \$20/kkg. The \$7/kkg figure is more applicable to the textile industry for wet sludge because the industry is located in a wet climate area of the country necessitating more leachate and runoff controls. Therefore the total cost for approved landfilling of wet sludge is \$9/kkg (includes \$2/kkg local hauling cost).

Unlike general purpose landfills, approved landfills are not usually found near a textile plant. In fact, approved landfills are almost non-existent in the southeastern part of the U.S. where most of the textile plants are located. Hauling costs are given in Figure 5-1, and are added to landfilling costs for the distance.

5.3.7 Cost Basis of Specialized Approved Landfills

Specialized approved landfills, constructed by the individual plants or companies, are not known to exist today in the textiles industry. They do exist in other industries (references 32 and 33). Even though the disposal costs are higher than those estimated for general purpose approved landfills, hauling costs reduce the difference. There is a possibility that treatment of leachate or runoff from on-site approved landfills could be accomplished by returning it to the plant wastewater treatment system, eliminating some leachate treatment costs. This would depend on the availability of land on or near the plant site.

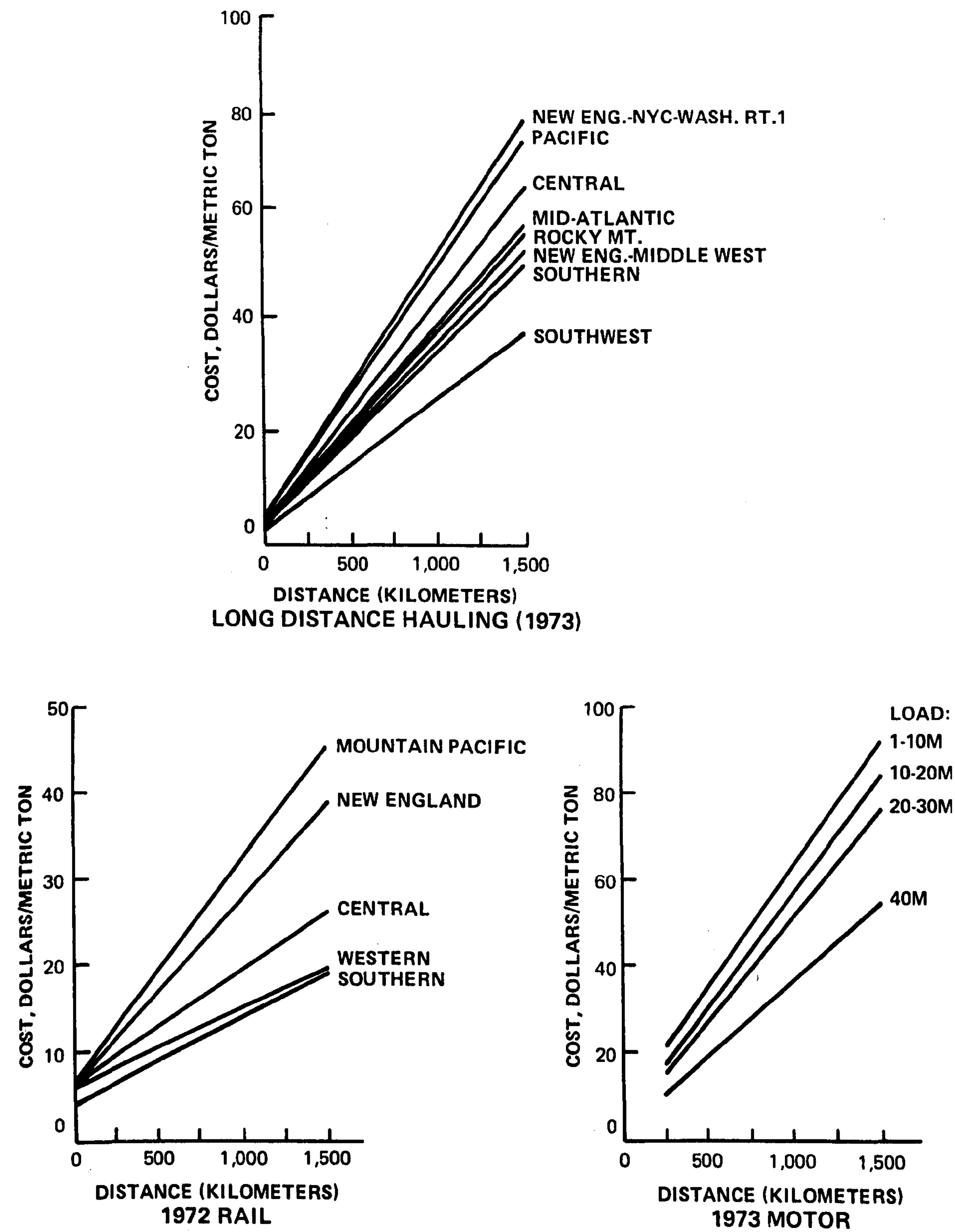
5.3.8 Cost Basis for Incineration

The cost for incineration per metric ton of sludge is much higher at the low volumes generated by the wastewater treatment systems of the textiles industry than at the high volumes common with municipal wastewater treatment systems (reference 32). On-site incineration of low volume, low solids sludges may be expected to cost \$100 to \$300 per metric ton of dry solids (references 34 and 35). Off-site contract incineration of these sludges will cost approximately \$100 per metric ton of dry solids (reference 32) handling and hauling charges to the contractor's facilities. An average cost of \$150/kkg of dry solids is estimated for incineration by a contractor.

5.3.9 Wet Oxidation Cost Basis

Wet oxidation of sludge was tried by at least one plant in the textiles industry and was found to be uneconomical because of the small volume of sludge.

Figure 5-1. REGIONAL TRANSPORTATION COSTS



5.3.10 Ocean Disposal Cost Basis

Textile plants apparently do not currently use ocean disposal. One plant had used this disposal method in the past, but discontinued the practice several years ago. Since most textile plants are not located close to the ocean, long distance hauling costs should be added to the following ocean disposal costs for wastewater treatment sludges:

Volume liters/week	Cost/liter ¢	Cost/kkg of Dry Solids 5% solids	Cost/kkg of Dry Solids 20% solids
3,800	1.5-2.1	\$300-\$400	\$75-\$105
38,000	0.8-1.0	\$160-\$200	\$40-\$50
378,500	0.6-0.85	\$120-\$170	\$30-\$42.50

These costs do not make ocean disposal an attractive option for most textile plants.

5.3.11 Chemical Fixation Cost Basis

Costs for chemical fixation treatment range from 0.7¢ to 1.6¢ per liter of sludge (reference 32). At a density of 1 kg/liter and a sludge solids content of 5 percent by weight, the cost is \$140 to \$320 per kkg of dry solids. At 20 percent solids content, the cost is \$35 to \$80 per kkg of dry solids.

5.3.12 Encapsulation Costs

Encapsulation in materials such as concrete, plastics or asphalt cannot compete costwise with other environmentally adequate disposal technologies for containers and wastewater treatment sludges. These techniques are normally reserved for small volume highly toxic materials such as radioactive wastes and pesticides.

5.3.13 Solvent Reclamation Cost

Aside from the cleaning and reuse of dye and chemical containers, the only other reclaim of potentially hazardous wastes is some of the miscellaneous solvent wastes. Costs for reclaiming solvents vary widely according to the specific waste.

5.4 Costs for Levels I, II, and III Technologies

The two general classifications of potentially hazardous land-destined wastes from the textiles industry are containers with residual dyes and chemicals and wastewater treatment sludges.

5.4.1 Container Waste Treatment and Disposal Costs by Industry Category

Industry categories A (Wool Scouring) and C (Gréige Goods) do not generate dye and chemical container wastes and therefore no treatment or disposal costs are required.

Tables 5-1 through 5-5 give the three levels of container waste treatment and disposal costs for industry categories B (Wool Fabric Dyeing and Finishing), D (Woven Fabric Dyeing and Finishing), E (Knit Fabric Dyeing and Finishing), F (Carpet Dyeing and Finishing) and G (Yarn and Stock Dyeing and Finishing). In all industry categories, the typical plant size is the average production rate of the category plants. The three levels of treatment and disposal are identical for typical plants in all industry categories and are as follows:

Level I — Off-site landfill by contractor

Level II — Washing containers free of residual dyes and chemicals prior to disposal

Level III — Same as Level II

Level I technology costs are based on a contractor fee of $15/kkg of waste disposal and are summarized as follows:

Cost Factor	Industry Range	Industry Average
$/kkg of product	0.005-0.046	0.028
$/kkg of wastestream	no range	15
$/kkg of hazardous waste	1,820-7,270	3,524

Levels II and III technology costs are the same and are based on a typical plant using one man-hour per week for 50 weeks to clean containers prior to disposal and are summarized as follows:

Cost Factor	Industry Range	Industry Average
$/kkg of product	0.05-0.24	0.10
$/kkg of wastestream	17-170	84
$/kkg of hazardous waste	2,300-62,600	23,900

The high cost per metric ton of hazardous waste result from the very small weight of the potentially hazardous constituents as compared to the total weight of the waste stream.

5.4.2 Wastewater Treatment Sludge Treatment/Disposal Costs by Industry Category

Industry category C (Greige Goods) does not generate wastewater treatment sludges containing potentially hazardous constituents and therefore no treatment and disposal costs are incurred. Plants having their own wastewater treatment system in all other industry categories do or will incur sludge treatment and disposal costs for at least one of the three technology

Table 5-1 Category B Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	2,800 kkg/yr.	Eastern U. S.	Wool Fabric Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount for Treatment/Disposal**
Dye and Chemical Containers	Fiber Drums and Paper Bags with Residual Dyestuff and Chemicals	Solid	2.9 kg/kkg of Product Total Containers 0.024 kg/kkg of Product Total Hazardous Residuals

Treatment/Disposal Costs/Levels	Dollars (1975)* Level I	Level II	Level III
Investment Costs			
Land	0	0	0
Other	0	0	0
Total Fixed	0	0	0
Annual Costs			
Capital Costs	0	0	0
Operating	0	0	250
Maintenance	0	0	0
Energy & Power	0	0	0
Contract Services	122	122	0
Total Annualized	122	122	250
Cost/kkg of product	0.044	0.044	0.09
Cost/kkg of potentially hazardous waste	15	15	30.79
Cost/kkg of hazardous constituents	1,820	1,820	3,720

Description of Treatment/Disposal Technology:

Level I Off-site landfill by contractor

Level II Same as Level I

Level III Washing containers free of residual dyes and chemicals prior to disposal

* To convert costs to December, 1973 dollars, multiply by 0.82.

Table 5-2 Category D Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	2,800 kkg/yr.	Southeastern U.S.	Woven Fabric Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount for Treatment/Disposal**
Dye and Chemical Containers	Fiber Drums and Paper Bags with Residual Dyestuff and Chemicals	Solid	1.24 kg/kkg of Product Total Containers 0.006 kg/kkg of Product Total Hazardous Residuals

Treatment/Disposal Costs/Levels	Dollars (1975)* Level I	Level II	Level III
Investment Costs			
Land	0	0	Same as Level II
Other	0	0	
Total Fixed	0	0	
Annual Costs			
Capital Costs	0	0	
Operating	0	250	
Maintenance	0	0	
Energy & Power	0	0	
Contract Services	52	0	
Total Annualized	52	250	
Cost/kkg of product	0.019	0.09	0.09
Cost/kkg of potentially hazardous waste	15	72	72
Cost/kkg of hazardous constituents	3,100	15,000	15,000

Description of Treatment/ Disposal Technology:

Level I Off-site landfill by contractor

Level II Washing containers free of residual dyes and chemicals prior to landfilling.

Level III Same as Level II

* To convert costs to December, 1973 dollars, multiply by 0.82.

Table 5-3 Category E Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	1,050 kkg/yr.	Southeastern U.S.	Knit Fabric Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount for Treatment/Disposal**
Dye and Chemical Containers	Fiber Drums and Paper Bags with Residual Dyestuff and Chemicals	Solid	1.82 kg/kkg of Product Total Containers 0.0038 kg/kkg of Product Total Hazardous Residuals

Treatment/Disposal Costs/Levels	Dollars (1975)* Level I	Level II	Level III
Investment Costs			
Land	0	0	same
Other	0	0	as
Total Fixed	0	0	Level II
Annual Costs			
Capital Costs	0	0	
Operating	0	250	
Maintenance	0	0	
Energy & Power	0	0	
Contract Services	29	0	
Total Annualized	29	250	
Cost/kkg of product	0.028	0.24	0.24
Cost/kkg of potentially hazardous waste	15	130	130
Cost/kkg of hazardous constituents	7,270	62,600	62,600

Description of Treatment/ Disposal Technology:

Level I Off-site landfill by contractor

Level II Washing containers free of residual dyes and chemicals prior to landfilling

Level III Same as Level II

* To convert costs to December, 1973 dollars, multiply by 0.82.

Table 5-4 **Category F** Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	4,720 kkg/yr.	Southeastern U.S.	Carpet Dyeing and Finishing
Identification of Waste Stream(s)	Composition of Waste	Physical Form	Amount for Treatment/Disposal
Dye and Chemical Containers	Fiber Drums and Paper Bags with Residual Dyestuff and Chemicals	Solid	0.31 kg/kkg of Product Total Containers 0.0014 kg/kkg of Product Total Hazardous Residual

Treatment/Disposal Costs/Levels	Dollars (1975)* Level I	Level II	Level III
Investment Costs			
Land	0	0	0
Other	0	0	0
Total Fixed	0	0	0
Annual Costs			
Capital Costs	0	0	0
Operating	0	0	250
Maintenance	0	0	0
Energy & Power	0	0	0
Contract Services	22	22	0
Total Annualized	22	22	250
Cost/kkg of product	0.005	0.005	0.05
Cost/kkg of potentially hazardous waste	15	15	170
Cost/kkg of hazardous constituents	3,330	3,330	35,700

Description of Treatment/ Disposal Technology:

Level I Off-site landfill by contractor

Level II Same as Level I

Level III Washing containers free of residual dyes and chemicals prior to landfilling

* To convert costs to December, 1973 dollars, multiply by 0.82

Table 5-5 Category G Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	4,800 kkg/yr.	Southeastern U.S.	Yarn and Stock Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount for Treatment/Disposal**
Dye and Chemical Containers	Fiber Drums and Paper Bags with Residual Dyestuff and Chemicals	Solid	3.07 kg/kkg of Product Total Containers 0.022 kg/kkg of Product Total Hazardous Residuals

Treatment/Disposal Costs/Levels	Dollars (1975) * Level I	Level II	Level III
Investment Costs			
Land	0	0	same
Other	0	0	as
Total Fixed	0	0	Level II
Annual Costs			
Capital Costs	0	0	
Operating	0	250	
Maintenance	0	0	
Energy & Power	0	0	
Contract Services	221	0	
Total Annualized	221	250	
Cost/kkg of product	0.046	0.05	0.05
Cost/kkg of potentially hazardous waste	15	17	17
Cost/kkg of hazardous constituents	2,100	2,300	2,300

Description of Treatment/ Disposal Technology:

Level I Off-site landfill by contractor

Level II Washing containers free of residual dyes and chemicals prior to landfilling

Level III Same as Level II

* To convert costs to December, 1973 dollars, multiply by 0.82

levels. It should be kept in mind that the costs developed for sludge wastestreams apply only to the typical plants in each category with their own wastewater treatment systems. As previously indicated, the ATMI has estimated that plants comprising 65% of industry production are direct discharge plants. However, the percentage of the number of plants in each category that have direct discharge is much less than 65% as shown previously in Table 4-3.

The location of typical plants in the various industry categories are all in either the eastern or southeastern part of the U.S. where the major part of the textiles industry is located. Process equipment age was not considered in the typical plant selection because it has no bearing on the amounts of sludge generated or wasted.

Costs were developed for typical plants in each industry category considering both the retention of sludge in aeration lagoons and the wasting of excess sludge from these lagoons. Categories A (Wool Scouring) and D (Woven Fabric Dyeing and Finishing) are the only two that typically waste sludge. Typical plants in the other industry categories have not yet found it necessary to waste sludge because of a low rate of solids buildup in their wastewater treatment systems. In all cases where sludges are retained in unlined lagoons, there is no cost for retaining the sludge. The costs for the aeration lagoons are attributed to wastewater treatment. However, costs for lining of these ponds to prevent leachate from reaching ground water were attributed to hazardous waste control. The annual costs for pond lining can be related to annual production as cost/kkg of product. They cannot be related to the wastestream or any part of the wastestream because no information is available for the generation rate of the sludges in wastewater treatment ponds. The sludge may be generated and retained for periods of 5 to 10 years or more in some cases before permanent disposal becomes necessary.

5.4.2.1 Category A — Wool Scouring, Table 5-6

The typical plant in this industry category was costed for the following three levels of technology.

Level I	(1) Retention of sludge in unlined treatment ponds
	(2) General land disposal of wasted sludge
Level II	(1) Retention of sludge in concrete lined treatment ponds
	(2) Same as Level I
Level III	(1) Same as Level II
	(2) Disposal of wasted sludge in approved landfill

Table 5-6 Category A Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	5,600 kkg/yr.	Eastern U.S.	Wool Scouring
Identification of Waste Stream(s)	Composition of Waste	Physical Form	Amount* Wasted for Treatment/Disposal
(1) Retained Wastewater Treatment Sludge (2) Wasted Wastewater Treatment Sludge	Water, fibers, grease biological + chemical suspended solids with adsorbed heavy metals and chlorinated organics	Liquid-solid sludge	(wet) 5,700 kg/kkg of Product (dry) 570 kg/kkg of Product Containing: 3.0 kg/kkg of product heavy metals 0.00073 kg/kkg of product chlor. organics

Dollars (1975)***

Treatment/Disposal Costs/Levels	Level I (1)	Level I (2)	Level II (1)	Level II (2)	Level III (1)	Level III (2)
Investment Costs						
Land	0	0	0	same	same	0
Other	0	20,000	57,500	as	as	0
Total Fixed	0	20,000	57,500	Level I	Level II	
Annual Costs						
Capital Costs	0	5200	6750			0
Operating	0	60,000	0			0
Maintenance	0	3,000	4400			0
Energy & Power	0	800	0			0
Contract Services	0	0	0			144,000
Total Annualized	0	69,000	11,150			144,000
Cost/kkg of product	0	12.32	2.00	12.32	2.00	25.71
Cost/kkg of wet sludge	0	2.16	NA	2.16	NA	4.51
Cost/kkg of dry sludge**	0	21.60	NA	21.60	NA	45.10

NA = Not applicable

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) General land disposal of wasted sludge

Level II (1) Retention of sludge in concrete lined treatment ponds (0.38 ha.)
(2) Same as Level I

Level III (1) Same as Level II
(2) Disposal of wasted sludge in approved landfill

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is: 7,800 kg (wet), 780 kg (dry) containing 4.1 kg total heavy metals and 0.001 kg total chlorinated organics.

**Solids in sludge contain potentially hazardous constituents.

***To convert costs to December, 1973 dollars, multiply by 0.82.

Level I costs were developed assuming:

a. an investment of $20,000 for a sludge truck amortized over 5 years.

b. a $2/kkg of liquid sludge disposal cost.

Level II costs were developed assuming:

a. an investment of $57,500 to line a 0.38 ha. treatment pond with concrete amortized over 20 years.

b. a maintenance cost of $4400/year to clean the lined pond every 5 years for inspection and repair of damage.

c. a $2/kkg of liquid sludge disposal cost.

Level III costs were developed assuming:

a. same as Level II, a. and b. above.

b. a $45/kkg of dry solids sludge approved contractor landfill disposal cost. This cost will be higher if the approved landfill is not local (within 20 miles) to the plant.

The total costs for each level of technology are summarized below:

Cost Factor	Level I	Total Cost Level II	Level III
$/kkg of product	12.32	14.32	27.21
$/kkg of waste stream	2.16	2.16	4.51
$/kkg of dry sludge	21.60	21.60	45.10

5.4.2.2 Category B — Wool Fabric Dyeing and Finishing, Table 5-7

The typical plant in this industry category was costed for the following three levels of technology:

Level I	(1)	Retention of sludge in unlined treatment ponds
	(2)	The practice of wasting sludge was not found in this category
Level II	(1)	Same as Level I
	(2)	Same as Level II
Level III	(1)	Retention of sludge in 20 mil PVC lined treatment ponds (0.89 ha.)
	(2)	Same as Level I

Table 5-7 **Category B** Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	5,200 kkg/yr.	Eastern U.S.	Wool Fabric Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount* Wasted for Treatment/Disposal**
(1) Retained Wastewater Treatment Sludge (2) Wasted Wastewater Treatment Sludge	Water, fibers, biological + chemical suspended solids with adsorbed heavy metals and dyestuff	Liquid-solid sludge	(wet) 0 kg/kkg of Product (dry) 0 kg/kkg of Product

Treatment/Disposal Costs/Levels	Dollars (1975)*** Level I (1)	Level I (2)	Level II (1)	Level II (2)	Level III (1)	Level III (2)
Investment Costs						
Land	0	NA	same	NA	0	NA
Other	0		as		80,430	
Total Fixed	0		Level I		80,430	
Annual Costs						
Capital Costs	0				9440	
Operating	0				0	
Maintenance	0				9400	
Energy & Power	0				0	
Contract Services	0				0	
Total Annualized	0				18,840	
Cost/kkg of product	0		0		3.62	
Cost/kkg of wet sludge	0		0		NA	
Cost/kkg of dry sludge**	0		0		NA	

NA = Not applicable

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) The practice of wasting sludge was not found in this category

Level II (1) Same as Level I
(2) Same as Level II

Level III (1) Retention of sludge in 20 mil PVC lined treatment ponds (0.89 ha.)
(2) Same as Level I

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is:
20,000 kg (wet), 1.6 kg (dry) containing 0.034 kg total heavy metals and 0.08 kg total dyestuff.

**solids in sludge contain potentially hazardous constituents

*** To convert costs to December, 1973 dollars, multiply by 0.82.

Levels I and II costs were developed assuming:

a. no cost for present sludge retention.

b. no cost for sludge disposal.

Level III costs were developed assuming:

a. an investment of $80,430 to line a 0.89 ha. treatment pond with 20 mil PVC amortized over 20 years.

b. a maintenance cost of $9,400/yr to clean the lined pond every 5 years for inspection and repair of damage.

c. no cost for sludge disposal.

The total costs for each level of technology are summarized below.

Cost Factor	Level I	Total Cost Level II	Level III
$/kkg of product	0	0	3.62
$/kkg of waste stream	0	0	not applicable
$/kkg of dry sludge	0	0	not applicable

5.4.2.3 Category C — Greige Goods

There are no potentially hazardous waste streams in this industry category and therefore no costs are incurred.

5.4.2.3 Category D — Woven Fabric Dyeing and Finishing, Table 5-8

The typical plant in this industry category was costed for the following three levels of technology:

Level I	(1)	Retention of sludge in unlined treatment ponds
	(2)	General land disposal of wasted sludge
Level II	(1)	Same as Level I
	(2)	Same as Level I
Level III	(1)	Retention of sludge in 20 mil PVC lined treatment ponds (0.38 ha.)
	(2)	Disposal of wasted sludge in approved landfill

Levels I and II costs were developed assuming:

a. no cost for present sludge retention.

b. an investment of $20,000 for a sludge truck amortized over 5 years.

c. a $2/kkg of liquid sludge disposal cost.

Table 5-8 **Category D** Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	5,600 kkg/yr.	Southeastern U.S.	Woven Fabric Dyeing and Finishing
Identification of Waste Stream(s)	Composition of Waste	Physical Form	Amount* Wasted for Treatment/Disposal
(1) Retained Wastewater Treatment Sludge (2) Wasted Wastewater Treatment Sludge	Water, fibers, biological + chemical suspended solids with adsorbed heavy metals and chlorinated organics and dyestuff	Liquid-solid sludge Containing: 1.0 kg/kkg of Product Dyestuff	(wet) 2300 kg/kkg of Product (dry) 20 kg/kkg of Product 0.19 kg/kkg of Product Heavy Metals 1.3 x 10^{-3} kg/kkg of Product chlor. organics

Treatment/Disposal Costs/Levels (1975) Dollars****	Level I (1)	Level I (2)	Level II (1)	Level II (2)	Level III (1)	Level III (2)
Investment Costs						
Land	0	0	same as Level I	same as Level I	0	0
Other	0	20,000			33,900	70,000
Total Fixed	0	20,000			33,900	70,000
Annual Costs						
Capital Costs	0	5,200			3,980	11,400
Operating	0	22,300			0	15,000
Maintenance	0	3,000			4,250	1,000
Energy & Power	0	500			0	500
Contract Services	0	0			0	5,000
Total Annualized	0	31,000			8,230	32,900
Cost/kkg of product	0	5.54	0	5.54	1.47	5.88***
Cost/kkg of wet sludge	0	2.41	0	2.41	NA	58.75***
Cost/kkg of dry sludge**	0	277	0	277	NA	294***

NA = Not applicable

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) General land disposal of wasted sludge

Level II (1) Same as Level I
(2) Same as Level I

Level III (1) Retention of sludge in 20 mil PVC lined treatment ponds (0.38 ha.)
(2) Disposal of wasted sludge in approved landfill

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is:
7,300 kg (wet), 67 kg (dry) containing 0.63 kg total heavy metals, 0.001 kg total chlorinated organics and 3.4 kg total dyestuff.

**Solids in sludge contain potentially hazardous constituents

***Costs apply to sludge dewatered to 25% solids.

**** To convert costs to December, 1973 dollars, multiply by 0.82.

Level III costs were developed assuming:

a. an investment of $33,900 to line a 0.38 ha. treatment pond with 20 mil PVC amortized over 20 years.

b. a maintenance cost of $4,250/year to clean the lined pond every 5 years for inspection and repair of damage.

c. an investment of $70,000 for sludge dewatering equipment amortized over 10 years.

d. an annual expense of $16,500 to operate and maintain the dewatering equipment.

e. a $45/kkg of dry solids sludge (dewatered to 20 percent solids) approved landfill by a contractor disposal cost. This cost will be higher if the approved landfill is not local (within 20 miles) to the plant.

The total costs for each level of technology are summarized below.

		Total Cost	
Cost Factor	Level I	Level II	Level III
$/kkg of product	5.54	5.54	7.35
$/kkg of waste stream	2.41	2.41	58.75
$/kkg of dry sludge	277	277	294

5.4.2.5 Category E -- Knit Fabric Dyeing and Finishing, Table 5-9

The typical plant in this industry category was costed for the following three levels of technology.

Level I	(1) Retention of sludge in unlined treatment ponds (2) The practice of wasting sludge is not typical in this category
Level II	(1) Retention of sludge in concrete lined treatment ponds (0.38 ha.) (2) Same as Level I
Level III	(1) Same as Level II (2) Same as Level I

Level I costs were developed assuming:

a. no cost for present sludge retention.

b. no cost for sludge disposal.

Table 5-9 Category E Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	4,000 kkg/yr.	Southeastern U.S.	Knit Fabric Dyeing and Finishing
Identification of Waste Stream(s)	**Composition of Waste**	**Physical Form**	**Amount* Wasted for Treatment/Disposal**
(1) Retained Wastewater Treatment Sludge	Water, fibers, biological + chemical suspended solids with adsorbed heavy metals, chlorinated organics + dyestuff	Liquid-solid sludge	(wet) 0 kg/kkg of Product
(2) Wasted Wastewater Treatment Sludge			(dry) 0 kg/kkg of Product

Treatment/Disposal Costs/Levels	Dollars (1975) ***					
	Level I		Level II		Level III	
	(1)	(2)	(1)	(2)	(1)	(2)
Investment Costs						
Land	0	NA	0	NA	same as Level II	NA
Other	0		57,500			
Total Fixed	0		57,500			
Annual Costs						
Capital Costs	0		6,750			
Operating	0		0			
Maintenance	0		4,400			
Energy & Power	0		0			
Contract Services	0		0			
Total Annualized	0		11,150			
Cost/kkg of product	0		2.79		2.79	
Cost/kkg of wet sludge	0		NA		NA	
Cost/kkg of dry sludge**	0		NA		NA	

NA = Not applicable

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) The practice of wasting sludge is not typical in this category

Level II (1) Retention of sludge in concrete lined treatment ponds (0.38 ha.)
(2) Same as Level I

Level III (1) Same as Level II
(2) Same as Level I

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is:
9600 kg (wet), 64 kg (dry) containing 0.32 kg total heavy metals, 0.0041 kg total chlorinated organics and 3.2 kg total dyestuff.

**Solids in sludge contain potentially hazardous constituents.

*** To convert costs to December, 1973 dollars, multiply by 0.82.

Levels II and III costs were developed assuming:

a. an investment of $57,500 to line a 0.38 ha. treatment pond with concrete amortized over 20 years.

b. a maintenance cost of $4,400/year to clean the lined pond every 5 years for inspection and repair of damage.

c. no cost for sludge disposal.

The total costs for each level of technology are summarized below.

Cost Factor	Level I	Total Cost Level II	Level III
$/kkg of product	0	2.79	2.79
$/kkg of waste stream	0	not applicable	not applicable
$/kkg of dry sludge	0	not applicable	not applicable

5.4.2.6 Category F -- Carpet Dyeing and Finishing, Table 5-10

The typical plant in this industry category was costed for the following three levels of technology:

Level I	(1)	Retention of sludge in unlined treatment ponds
	(2)	The practice of wasting sludge is not typical in this category
Level II	(1)	Same as Level I
	(2)	Same as Level I
Level III	(1)	Retention of sludge in 20 mil PVC lined treatment ponds (0.38 ha.)
	(2)	Same as Level I

Levels I and II costs were developed assuming:

a. no cost for present sludge retention.

b. no cost for sludge disposal.

Level III costs were developed assuming:

a. an investment of $33,900 to line a 0.38 ha. treatment pond with 20 mil PVC amortized over 20 years.

b. a maintenance cost of $4,250/year to clean the lined pond every 5 years for inspection and repair of damage.

c. no cost for sludge disposal.

Table 5-10 Category F Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	10,000 kkg/yr.	Southeastern U.S.	Carpet Dyeing and Finishing
Identification of Waste Stream(s)	Composition of Waste	Physical Form	Amount* Wasted for Treatment/Disposal
(1) Retained Wastewater Treatment Sludge (2) Wasted Wastewater Treatment Sludge	Water, fibers, biological + chemical suspended solids with adsorbed heavy metals, chlorinated organics + dyestuff	Liquid-solid Sludge	(wet) 0 kg/kkg of Product (dry) 0 kg/kkg of Product

Treatment/Disposal Costs/Levels	Dollars (1975)*** Level I (1)	Level I (2)	Level II (1)	Level II (2)	Level III (1)	Level III (2)
Investment Costs						
Land	0	NA	same	NA	0	NA
Other	0		as		33,900	
Total Fixed	0		Level I		33,900	
Annual Costs						
Capital Costs	0				3,980	
Operating	0				0	
Maintenance	0				4,250	
Energy & Power	0				0	
Contract Services	0				0	
Total Annualized	0				8,230	
Cost/kkg of product	0		0		0.82	
Cost/kkg of wet sludge	0		0		NA	
Cost/kkg of dry sludge**	0		0		NA	

NA = Not applicable

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) The practice of wasting sludge is not typical in this category

Level II (1) Same as Level I
(2) Same as Level I

Level III (1) Retention of sludge in 20 mil PVC lined treatment ponds (0.38 ha.)
(2) Same as Level I

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is:
22,000 kg (wet), 5.2 kg (dry) containing 0.041 kg total heavy metals, 1.4×10^{-4} kg total chlorinated organics and 0.26 kg total dyestuff.

**Solids in sludge contain potentially hazardous constituents.

*** To convert costs to December, 1973 dollars, multiply by 0.82.

The total costs for each level of technology are summarized below.

Cost Factor	Level I	Total Cost Level II	Level III
\$/kkg of product	0	0	0.82
\$/kkg of waste stream	0	0	not applicable
\$/kkg of dry sludge	0	0	not applicable

5.4.2.7 Category G — Yarn and Stock Dyeing and Finishing, Table 5-11

The typical plant in this industry category was costed for the following three levels of technology:

Level I	(1) Retention of sludge in unlined treatment ponds (2) The practice of wasting sludge is not typical in this category
Level II	(1) Same as Level I (2) Same as Level I
Level III	(1) Retention of sludge in 20 mil PVC lined treatment ponds (0.89 ha.) (2) Same as Level I

Levels I and II costs were developed assuming:

a. no cost for present sludge retention.

b. no cost for sludge disposal.

Level III costs were developed assuming:

a. an investment of \$80,430 to line a 0.89 ha. treatment pond with 20 mil PVC amortized over 20 years.

b. a maintenance cost of \$9,400/year to clean the lined pond every 5 years for inspection and repair of damage.

c. no cost for sludge disposal.

The total costs for each level of technology are summarized below:

Cost Factor	Level I	Total Cost Level II	Level III
\$/kkg of product	0	0	1.11
\$/kkg of waste stream	0	0	not applicable
\$/kkg of dry sludge	0	0	not applicable

Table 5-11. Category G Typical Plant Costs For Treatment and Disposal, 1975

	Annual Production (1975)	Location	Manufacturing Process
Typical Plant Characteristics	17,000 kkg/yr.	Southeastern U.S.	Yarn and Stock Dyeing and Finishing
Identification of Waste Stream(s)	Composition of Waste	Physical Form	Amount* Wasted for Treatment/Disposal
(1) Retained Wastewater Treatment Sludge (2) Wasted Wastewater Treatment Sludge	Water, fibers, biological + chemical suspended solids with adsorbed heavy metals, chlorinated organics and dyestuff	Liquid-solid sludge	(wet) 0 kg/kkg of Product (dry) 0 kg/kkg of Product

Treatment/Disposal Costs/Levels	Dollars (1975) ***					
	Level I		Level II		Level III	
	(1)	(2)	(1)	(2)	(1)	(2)
Investment Costs						
Land	0	NA	same	NA	0	NA
Other	0		as		80,430	
Total Fixed	0		Level I		80,430	
Annual Costs						
Capital Costs	0				9,440	
Operating	0				0	
Maintenance	0				9,400	
Energy & Power	0				0	
Contract Services	0				0	
Total Annualized	0				18,840	
Cost/kkg of product	0		0		1.11	
Cost/kkg of wet sludge	0		0		NA	
Cost/kkg of dry sludge**	0		0		NA	

Description of Treatment/ Disposal Technology:

Level I (1) Retention of sludge in unlined treatment ponds
(2) The practice of wasting sludge is not typical in this category

Level II (1) Same as Level I
(2) Same as Level I

Level III (1) Retention of sludge in 20 mil PVC lined treatment ponds (0.89 ha.)
(2) Same as Level I

*The amount of sludge retained cannot be based on the production rate. The estimated amount retained by this typical plant is:
20,000 kg (wet), 2.9 kg (dry) containing 0.01 kg total heavy metals, 1.2×10^{-4} kg total chlorinated organics and 0.14 kg total dyestuff.

**Solids in sludge contain potentially hazardous constituents.

*** To convert costs to December, 1973 dollars, multiply by 0.82.

5.5 Extrapolation of Technology Costs to the Industry Categories and the Entire Industry

Table 5-12 summarizes the estimated treatment and disposal costs for the whole of the industry categories and the entire textiles industry. The costs relate only to that part of the industry category that presently or will utilize the technologies cited. The following is an example of the methodology used to extrapolate the costs for Category D, Woven Fabric Dyeing and Finishing:

Level I

$$\text{Total category cost} = 1{,}801 \times \left[(0.019xa) + (5.54xb \times c)\right]$$

Level II

$$\text{Total category cost} = 1{,}801 \times \left[(0.09xa) + (5.54xb \times c)\right]$$

Level III

$$\text{Total category cost} = 1{,}801 \times \left[(0.09xa) + (1.47xb) + (5.88xb \times c)\right]$$

where 1,801 = total category production in kkg x 10^3

0.019, 5.44, 0.09, 1.47 and 5.88 = \$/kkg of product for each technology taken from Tables 5-2 and 5-8

a = 1.0 = ratio of production in category that has container wastes

b = 0.65 = ratio of production in category with direct discharge

c = 0.56 = ratio of direct discharge production that wastes sludge

The estimated total annual costs for the entire industry at the three levels of technology are \$4,664,600, \$6,532,800 and \$11,704,000 respectively. The total industry rates in terms of \$/kkg of product are 0.88, 1.24 and 2.21 respectively. The difference between what the industry is presently spending and what is required for adequate health and environmental protection is approximately \$7,000,000. This amounts to only \$1.32/kkg of total production.

5.6 Comparison of Technology Costs with Sales Values for the Industry Categories and the Entire Industry

Table 5-13 summarizes the technology costs as a percent of sales value for the various industry categories and the entire industry. The sales values on the table were taken from 1972 Census of Manufacturers reports and upgraded to 1975 values by assuming a 5% per year increase.

Table 5-12

Extrapolation of Technology Costs to the Industry Categories and the Entire Textiles Industry

Industry Category	Annual Production Thousand Metric Tons	Annual Costs, 1975 Dollars* Level I	Level II	Level III
A - Wool Scouring	69	850,000	988,000	1,910,000
B - Wool Fabric Dyeing and Finishing	309	13,600	13,600	754,000
C - Greige Goods	3,000	No potentially hazardous wastes - no technology costs		
D - Woven Fabric Dyeing and Finishing	1,801	3,700,000	3,800,000	5,740,000
E - Knit Fabric Dyeing and Finishing	771	21,600	1,600,000	1,600,000
F - Carpet Dyeing and Finishing	679	3,400	3,400	400,000
G - Yarn and Stock Dyeing and Finishing	1,660	76,000	83,000	1,300,000
TOTAL Industry	5,289*	4,664,600	6,488,000	11,704,000
TOTAL Industry Rate	$/kkg of product	0.88	$1.23	$2.21
	$/kkg of potentially hazardous waste (dry weight)	$97.	$134	$242
	$/kkg of potentially hazardous waste (wet weight)	$2.40	$3.35	$6.03

* To convert costs to December, 1973 dollars, multiply by 0.82

** Does not include Category C - Greige Goods

Table 5-13

Comparison of Technology Costs With the Total Sales by Industry Category and the Entire Textiles Industry

Industry Category	Sales Value* $/kkg	Technology Costs as Percent of Sales Value		
		Level I	Level II	Level III
A - Wool Scouring	3,000	0.4	0.5	0.9
B - Wool Fabric Dyeing and Finishing	1,650	0.003	0.003	0.15
C - Greige Goods	No potentially hazardous wastes - no technology costs			
D - Woven Fabric Dyeing and Finishing	1,280	0.16	0.16	0.25
E - Knit Fabric Dyeing and Finishing	1,840	0.0015	0.11	0.11
F - Carpet Dyeing and Finishing	1,850	0.0003	0.0003	0.032
G - Yarn and Stock Dyeing and Finishing	450	0.01	0.01	0.17
Weighted Average For Entire Industry	1,218	0.07	0.1	0.18

*1975 Dollars

Values are less than 1% for all industry categories at all three technology levels. The weighted average values for the entire industry at the three levels of technology are 0.07%, 0.1% and 0.18% respectively. For less than 0.2% of the sales value, the entire industry can provide treatment/disposal technology for potentially hazardous land-destined wastes that will give adequate health and environmental protection.

5.7 Treatment/Disposal costs for Miscellaneous Atypical Potentially Hazardous Textiles Industry Wastes

Table 5-14 summarizes the current treatment/disposal costs for the miscellaneous wastes listed in Table 4-4. These costs have not been extrapolated for the entire industry because there is insufficient information on the frequency of their occurrence. For some plants the costs of treating and disposing of these wastes may be more significant than those for either wastewater treatment sludges or dye and chemical containers.

Table 5-14

Costs for Treatment/Disposal of Miscellaneous Atypical Potentially Hazardous Textile Industry Wastes

Subcategory *	Waste Description	Quantity kg/kkg of product	Present Treatment/Disposal	Present Cost $/year
A	none	none	--	--
B	Still bottoms from recovery of chlorinated solvents	5	landfill or dump	100
D	Hydrocarbon solvent and sludges	50	landfill	5,000
D	Finishing sludges containing adhesives, silicones and solvents	333	landfill	1,500
E	Acetone recovery still bottoms	63	incineration	7,150
E	Perchloroethylene still bottoms	10	reclaimed by contractor	no charge
F	Lint with wet dye	12	landfill	10,800
G	Solvent and resin slurries	0.09	landfilled	100

* A - Wool Scouring
B - Wool Fabric D & F
D - Woven Fabric D & F
E - Knit Fabric D & F
F - Carpet D & F
G - Yarn and Stock D & F

6.0 REFERENCES AND ADDITIONAL SOURCES OF INFORMATION

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7.0 ACKNOWLEDGEMENTS

The preparation of this report was accomplished through the efforts of the staff of General Technologies Division, Versar Inc., Springfield, Virginia, under the direction of Mr. Edwin F. Abrams, Program Manager.

Mr. Matthew A. Straus, Project Officer, Timothy Fields, Jr., Acting Program Manager, and William Sanjour, Branch Chief, Hazardous Waste Division, through their assistance, leadership, advice and careful review of the draft report have made an invaluable contribution to the preparation of this report.

Appreciation is extended to the following trade associations for assistance and cooperation in this program:

American Textile Manufacturers Institute

Carpet and Rug Institute

Northern Textile Association

Appreciation is also extended to the many textile companies, state and federal agencies who gave us invaluable assistance and cooperation in this program. Also, our appreciation is extended to the individuals of the technical staff of General Technologies Division of Versar Inc., for their assistance during this program. Specifically our thanks to:

Dr. Robert G. Shaver, Vice President

Mrs. D. K. Guinan, Environmental Chemist

Mr. D. L. Derkics, Environmental Scientist

Mr. S. Powers, Environmental Scientist

Dr. L. Parker, Senior Chemical Engineer

Mr. M. C. Calhoun, Field Engineer

Dr. M. Khattak, Analytical Chemist

Mr. F. Fortess, Consultant

Mr. H. Henderson, Consultant

Acknowledgement and appreciation is also given to the secretarial staff of General Technologies Division of Versar Inc. for their efforts in the typing of drafts, necessary revisions, and final preparation of this document.

APPENDIX A

GLOSSARY

Accelerant - A chemical used to speed up chemical or other processes. For example, accelerants are used in dyeing triacetate and polyester fabrics.

Acid Dyes - See Dyes.

Actinic Resistance - Ability to retain strength and resist deterioration on exposure to sunlight.

Activated Carbon - Charcoal, mostly of vegetable origin, of high absorptive capacity. It is used for decolorizing liquids and other adsorption purifications. Usually made by carbonization and chemical activation.

Aesthetics - In textiles, properties perceived by touch and sight, such as the hand, color, luster, drape, and texture of fabrics and garments.

After treatment - A term which is normally used in relation to processes carried out after dyeing or printing to improve fastness properties and/or to produce normal shades.

Ageing - 1. The deterioration of textile or other materials caused by the gradual oxidation in storage and/or exposure to light. 2. The oxidation stage of alkali-cellulose in the manufacture of viscose rayon from bleached wood pulp. 3. Originally a process in which printed fabric was exposed to a hot, moist atmosphere. Presently, the term is applied to the treatment of printed fabric in moist steam in the absence of air. Ageing is also used for the development of certain colors in dyeing, e.g., aniline black.

Ager - A steam chamber used for the ageing of printed or padded material.

Aniline Dyes - See dyes.

Animal Fibers - Fibers of animal origin such as wool, alpaca, camel hair, and silk.

Anthraquinone Dyes - See Dyes.

Azo Dyes - See Dyes.

Azoic Dyes - See Dyes, Naphthol Dyes.

Backcoating - The application of latex or adhesive to the back of a carpet to anchor the tufts, usually followed immediately by the addition of a secondary backing material such as woven jute or nonwoven polypropylene.

Backing - 1. A general term for any system of yarn which interlaces on the back of a textile material. 2. A knit or woven fabric or plastic foam bonded to a face fabric. 3. A knit or woven fabric bonded to a vinyl or other plastic sheet material. 4. See Carpet Backing.

Backwinding - 1. Rewinding yarn from one type of package to another. 2. Winding yarn as it is deknit.

Balling Up - A yarn defect in which loose of frayed fibers form into a ball and are then woven into the fabric.

Basic Dyes - See Dyes.

BCF Yarns - Bulked continuous filament yarns for carpet trade, mostly nylon but occasionally polypropylene.

Beam - A cylinder of wood or metal, usually with a circular flange on each end, on which warp yarns are wound for slashing, weaving, and warp knitting.

Beam Dyeing Machine - A high-temperature dyeing machine for dyeing warp yarns or fabrics which have been wound onto a special beam, the barrel of which is evenly perforated with holes. The dye liquor is forced through the yarn or fabric from inside to outside.

Beaming - The operation of winding warp yarns onto a beam in preparation for slashing, weaving, or warp knitting.

Beck - A vessel for dyeing fabric in rope form, consisting primarily of a tank and a reel to advance the fabric.

Bleaching - Any of several processes to remove the natural and artificial impurities in fabrics to obtain clear whites for finished fabric or in preparation for dyeing and finishing.

Bleeding - Loss of color by a fabric or yarn when immersed in water, a solvent, or a similar liquid medium, as a result of improper dyeing or the use of dyes of poor quality. Fabrics that bleed cause staining of white or light shade fabrics in contact with them while wet.

Blending - The combining of staple fibers of different physical characteristics to assure a uniform distribution of these fibers throughout the yarn.

Bonded Fabric - A fabric containing two or more layers of cloth joined together with resin, rubber, foam, or adhesive to form one ply.

Brushing - A finishing process in which rotating brushes raise a nap on knit or woven fabrics. Brushing is used on sweaters, scarves, knit underwear, wool broadcloths, etc.

Calendering - A mechanical finishing process for fabrics to produce special effects, such as high luster, glazing, moiré, and embossed effects. In this operation, the fabric is passed between heated rolls under pressure.

Carbonizing - A chemical process for eliminating cellulosic material from wool or other animal fibers. The material is reacted with sulfuric acid or hydrogen chloride gas followed by heating. When the material is dry the carbonized cellulose material is dust-like and can be removed.

Carding - A process in the manufacture of spun yarns whereby the staple is opened, cleaned, aligned, and formed into a continuous, untwisted strand called a sliver.

Carpet Backing - A primary backing through which the carpet tufts are inserted is always required for tufted carpets. The backing is usually made of woven jute or formed (nonwoven) man-made fiber fabrics. A secondary backing, again made of jute or man-made fibers, is normally added at the latex backcoating stage. Carpet backings are an important end use for formed fabrics.

Carpets - Heavy functional and ornamental floor coverings consisting of pile yarns or fibers and a backing system. They may be tufted or woven. Also see Tufted Carpet.

Carrier - 1. A product added to a dyebath to promote the dyeing of hydrophobic man-made fibers and characterized by the affinity for, and ability to swell, the fiber. 2. A moving holder for a package of yarn used on a braiding machine. 3. A term sometimes used to describe the tube or bobbin on which yarn is wound.

Cationic Dyes - See Dyes, Basic Dyes.

Cellulose Material - Material composed of or derived from cellulose (e.g., cotton, rayon, acetate and triacetate).

Chain Dyeing - See Dyeing.

Cheese - A cylindrical package of yarn wound on a flangeless tube.

Chelating Agent - A compound that will inactivate a metallic ion by making it an integral part of an inner ring structure. The metal is attached by coordinate links to two or more nonmetal atoms in the same molecule.

Circular-Knit Fabric - A tubular weft-knit fabric made on a circular-knitting machine.

Coated Fabric - A fabric to which a substance such as lacquer, plastic, resin, rubber, or varnish has been applied in firmly adhering layers to provide certain properties, such as water impermeability.

Combing - A step subsequent to carding in cotton and worsted system processing which straightens the fibers and extracts neps, foreign matter, and short fibers. Combing produces a stronger, more even, more compact, finer, smoother yarn.

Coning - The transfer of yarn from skeins or bobbins or other types of packages to cones.

Converted Fabric - A finished fabric as distinguished from greige fabric.

Converter - An individual or organization which buys greige fabrics and sells them as a finished product to cutters, wholesalers, retailers, and others. The converter arranges for the finishing of the fabric, namely bleaching, mercerizing, dyeing, printing, etc., to the buyers' specifications.

Crimp - The difference in distance between two points on an unstretched fiber and the same two points when the fiber is straightened under specified tension.

Crocking - The removal of dye from a fabric as a result of insufficient dye penetration or fixation. This is caused by the use of improper dyes or dyeing methods, or insufficient washing and treatment after the dyeing operation.

Cross Dyeing - See Dyeing.

Cut Pile - A pile surface obtained by cutting the loops of yarn in a tufted or woven carpet.

Decatizing (Decating) - A finishing process in which fabric,wound tightly on a perforated roller, either has hot water circulated through it (wet decatizing), or has steam blown through it (dry decatizing). The process is aimed chiefly at improving the hand and removing wrinkles.

Denier - A weight-per-unit-length measure of any linear material. Officially, it is the number of unit weights of 0.05 grams per 450-meter length. This is numerically equal to the weight in grams of 9,000 meters of the material.

Deregistering (crimp) - The process of disordering or disaligning the crimp in a tow band to produce bulk.

Developed Dyes - See Dyes.

Developing - A stage in dyeing or printing in which leuco compounds, dyes or dye intermediates are converted to the final, stable state or shade.

Dip Dyeing - See Dyeing.

Direct Dyes - See Dyes.

Direct Printing - See Printing.

Discharge Printing - See Printing.

Disperse Dyes - See Dyes.

Doctor Blade - A metal knife which cleans or scrapes the excess dye from engraved printing rollers, leaving dye paste only in the valleys of engraved areas. Also used to describe other blades which are used to apply materials evenly to rollers or fabrics.

Dope-Dyed - See Dyeing, Mass-Colored.

Double-Knit Fabric - A circular-knit fabric with a double thickness produced by using a double stitch on machines employing two sets of needles (dial and cylinder).

Drafting - See Drawing 1.

Drape - A term to describe the way a fabric falls while it hangs.

Drawing - 1. The process of attenuating or increasing the length per unit weight of laps, slivers, slubbings, or rovings. 2. The hot or cold stretching of continuous filament yarn or tow to align and arrange the crystalline structure of the molecules in order to achieve improved tensile properties.

Drying Cylinders - Any of a number of heated revolving cylinders for drying fabric or yarn. They are arranged either vertically or horizontally in sets, with the number varying according to the material to be dried. They are often internally heated with steam and Teflon-coated to prevent sticking.

Dyeing - A process of coloring fibers, yarn, or fabrics with either natural or synthetic dyes. Some of the major dyeing processes are described below:

a. Batik - A resist-dyeing process in which portions of a fabric are coated with wax, and during the dyeing process, only the uncovered areas take the dye. The process can be repeated so that several colors are used. Batik dyeing is often imitated in machine printing.

b. Chain Dyeing - A method of dyeing yarns and fabrics of low tensile strength by tying them end-to-end and running them through the dyebath in a continuous process.

c. Cross Dyeing - A method of dyeing blends or combination fabrics to two or more shades by the use of dyes with different affinities for the different fibers.

d. Dip Dyeing - A general term used for the dyeing of hosiery and other knit goods to differentiate with yarn dyeing. In this sense, it is synonymous with piece dyeing.

e. High-Temperature Dyeing - A dyeing operation in which the aqueous dyebaths are maintained at temperatures greater than 100° C by use of pressurized equipment. Used for many man-made fibers.

f. Ingrain - A term used to describe yarn or stock which is dyed in two or more shades prior to knitting or weaving to create blended color effects in fabrics.

g. Mass-Colored - A term to describe a man-made fiber (yarn, staple, or tow) which has been colored by the introduction of pigments or insoluble dyes into the polymer melt or spinning solution prior to extrusion. Usually, the colors are fast to most destructive agents.

h. Muff-Dyeing - A form of yarn dyeing in which the cone has been removed.

i. Package Dyeing - See Dyeing, Yarn Dyeing.

j. Pad Dyeing - A form of dyeing whereby a dye solution is applied by means of a padder or mangle.

k. Piece Dyeing - The dyeing of fabrics "in the piece", i.e., in fabric form after weaving or knitting as opposed to dyeing in the form of yarn or stock.

l. Pressure Dyeing - Dyeing by means of forced circulation of dye through packages of fiber, yarn, or fabric under superatmospheric pressure (100-200 psi).

m. Printing - See Printing.

n. Reserve Dyeing - 1. A method of dyeing in which one component of a blend or combination fabric is left undyed. The objective is accomplished by the use of dyes which are substantive to the fiber to be colored but which are not substantive to the fiber to be reserved. 2. A method of treating yarn or fabric so that in the subsequent dyeing operation the treated portion will not be dyed.

o. Skein Dyeing - The dyeing of yarn in the form of skeins, or hanks.

p. Solvent Dyeing - A dyeing method based on the solubility of the dye in some liquid other than water, although water may be present in the dyebath.

q. Space Dyeing - A yarn-dyeing process in which each strand is dyed with more than one color at irregular intervals. Space dyeing produces an effect of unorganized design in subsequent fabric form. The two primary methods are knit-de-knit and warp printing.

r. Spun Dyed - See Dyeing, Mass-Colored.

s. Stock Dyeing - The dyeing of fibers in staple form.

t. Thermal Fixation - A process for dyeing polyester, where the color is diffused into the fiber by means of dry heat.

u. Union Dyeing - A method of dyeing a fabric containing two or more fibers or yarns to the same shade so as to achieve the appearance of a solid colored fabric.

v. Yarn Dyeing - The dyeing of yarn before the fabric is woven or knit. Yarn can be dyed in the form of skeins, muffs, packages, cheeses, cakes, chain-warps, and beams.

Dyeing Auxiliaries - Various substances which can be added to the dyebath to aid dyeing. They may be necessary to transfer the dye from the bath to the fiber or they may provide improvements in leveling, penetration, etc. Also called dyeing assistants.

Dyes - Substances which add color to textiles by adsorption into the fiber. Dyes differ in their resistance to sunlight, perspiration, washing, gas, alkalies, and other agents; their affinity for different fibers; their reaction to cleaning agents and methods; and their solubility and method of application. Dyes are commercial preparations containing only approximately 50 per cent pure dyestuff, with the rest being some inert filler such as sugar and surfactants. Various classes and types are listed below:

a. Acid Dyes - A class of dyes used on wool and other animal fibers. Acid dyes are seldom used on cotton or linen since this process requires a mordant. Acid dyes are widely used on nylon when high washfastness is required. In some cases, even higher washfastness can be obtained by aftertreatment with fixatives. Acid dyes are comparatively small dye molecules with one or more sulfonic acid groups attached to the organic substrates.

b. Aniline Dyes - Dyes derived chemically from aniline or other coal tar derivatives. Aniline dyes are used mainly on cotton.

c. Anthraquinone Dyes - Dyes which have anthraquinone as their base and the carbonyl group $>C = O$ as the chromophore. Anthraquinone-based dyes are found in most of the synthetic dye classes.

d. Azo Dyes - Dyes characterized by the presence of the azo group -N=N- as the chromophore. Azo dyes are found in many of the synthetic dye classes. Azo dyes are used mainly on cotton and rayon fabrics.

e. Azoic Dyes - See Dyes, Naphthol Dyes.

f. Basic Dyes - A class of positive-ion-carrying dyes known for their brilliant hues. Basic dyes are composed of large-molecule, water-soluble salts which have a direct affinity for wool and silk and can be applied to cotton with a mordant. The fastness of basic dyes on these fibers is very poor. Basic dyes are also used on basic-dyeable acrylics, modacrylics, and polyesters, on which they exhibit reasonably good fastness.

g. Cationic Dyes - See Dyes, Basic Dyes.

h. Developed Dyes - Dyes which are formed by the use of a developer. The substrate is first dyed in a neutral solution with a dye base, usually colorless. The dye is then diazotized with sodium nitrite and an acid after which it is treated with a solution of p-naphthol, or a similar substance, which is the developer. Direct dyes are developed to produce a different shade or to improve washfastness and lightfastness. Developed dyes are used on both cotton and rayon fibers.

i. Direct Dyes - A class of dyestuffs which are applied directly to the substrate in a neutral or alkaline bath. They produce full shades on cotton and linen without mordanting and may also be applied to rayon, silk, and wool. Direct dyes give bright shades but exhibit poor washfastness. Various aftertreatments are used to improve the washfastness of direct dyes (such dyes are referred to as "aftertreated direct colors").

j. Disperse Dyes - A class of dyes which are only slightly water soluble originally introduced for dyeing acetate and usually applied from fine aqueous suspensions. Disperse dyes are widely used for dyeing most man-made fibers.

k. Fiber-Reactive Dyes - A type of water soluble anionic dye having an affinity for cellulose fibers. In the presence of an alkali, the dyes react with hydroxyl groups in the cellulose and thus are linked with the fiber. Fiber reactive dyes are relatively new dyes and are used extensively on cellulosics when bright shades are desired.

l. Metallized Dyes - A class of dyes that have metals in their molecular structure. They are applied from an acid bath. Metallized dyes are used on nylon, silk and wool.

m. Naphthol Dyes - A type of azo compound formed on the fiber by first treating the fiber with a phenolic compound. The fiber is then immersed in a second solution containing a diazonium salt which reacts with the phenolic compound to produce a colored azo compound. Since the phenolic compound is dissolved in a caustic solution, these dyes are mainly used for cellulose fibers, however, other fibers can be dyed by modifying the process. (Also see Developed Dyes).

n. Premetallized Dyes - Acid dyes which are treated with coordinating metals such as chromium. This type of dye has much better wet-fastness, than regular acid dyes. Premetallized dyes are used on nylon, silk and wool.

o. Sulfur Dyes - A class of water-insoluble dyes which are applied in a soluble, reduced form from a sodium sulfide solution which are then reoxidized to the insoluble form on the fiber. Sulfur dyes are mainly used on cotton for economical dark shades of moderate to good fastness to washing and light. They generally give very poor fastness to chlorine.

p. Vat Dyes - A class of water-soluble dyes which are applied to the fiber in a reduced, soluble form (leuco compound) and then reoxidized to the original insoluble form. Vat dyes are among the most resistant dyes to both washing and sunlight. They are widely used on cotton, linen, rayon and other vegetable fibers.

Dye Sites - Functional groups within a fiber which provide sites for chemical bonding with the dye molecule. Dye sites may be either in the polymer chain or in chemical additives included in the fiber.

Dyestuff - The chemical component of dyes that imparts the color to a fabric; usually a complex, organic compound.

Exhaustion - During wet processing, the ratio at any time between the amount of dye or substance taken up by the substrate and the amount originally available.

Extract Printing - See Printing, Discharge Printing.

Fastness - Resistance to facing; i.e., the property of a dye to retain its color when the dyed (or printed) textile material is exposed to conditions or agents such as light, perspiration, atmospheric gases, or washing that can remove or destroy the color. A dye may be reasonably fast to one agent and only moderately fast to another. Degree of fastness of color is tested by standard procedures. Textile materials often must meet certain fastness specifications for a particular use.

Feel - See Hand.

Fell - The end of a piece of fabric which is woven last.

Fiber-Reactive Dyes - See Dyes.

Filament - A fiber of indefinite or extreme length such as found naturally in silk. Man-made fibers are extruded into filaments which are converted into filament yarn, staple, or tow.

Filling - In a woven fabric, the yarn running from selvage to selvage at right angles to the warp. Each crosswise length is called a pick. In the weaving process, the filling yarn is carried by the shuttle or other type of yarn carrier.

Finish - 1. A substance or mixture of substances which are added to textile materials to impart desired properties. 2. A process, physical or chemical, applied to textile materials to produce a desired effect. 3. A property, such as smoothness, drape, luster,water repellency, flame retardancy or crease resistance which is produced by 1 and/or 2 above. 4. The state of a textile material as it leaves a process. (Also see Finishing).

Finishing - All the processes through which the fabric is passed after bleaching, dyeing, or printing in preparation for the market or use. Finishing includes such operations as heat-setting, napping, embossing, pressing, calendering, and the application of chemicals which change the character of the fabric. The term finishing is also sometimes used to refer collectively to all processing operations above, including bleaching, dyeing, printing, etc.

Fixation - The process of setting a dye after the dyeing or printing operation, usually by steaming or other heat treatment.

Flock - The material obtained by reducing textile fibers to fragments by cutting or grinding. There are two main types: precision cut flock, where all fiber lengths are approximately equal, and random cut flock, where the fibers are ground or chopped to produce a broad range of lengths.

Flocking - A method of cloth ornamentation in which adhesive is printed or coated on a fabric, and finely chopped fibers are applied all over by means of dusting, air-blasting, or electrostatic attraction. In flock printing, the fibers adhere only to the printed or coated areas and are removed from the unprinted areas by mechanical action.

Fly - The short, waste fibers that are released into the air in textile processing operations such as picking, carding, spinning, and weaving.

Formed Fabric - An assembly of textile fibers which are held together by the mechanical interlocking in a random web or mat, by fusing the fibers or by bonding with a cementing medium such as starch, glue, casein, rubber latex, or one of the cellulose derivatives or synthetic resins. Formed fabrics are used for expendable items, such as hospital sheets, napkins, diapers and wiping cloths, as the base material for the coated fabrics, and in a variety of other applications.

Fulling - A finishing process used in the manufacture of woolen and worsted fabrics. The cloth is subjected to moisture, heat, friction, chemicals, and pressure which cause it to mat and shrink appreciably in both the warp and filling directions, resulting in a denser, more compact fabric.

Garnetting - A process for reducing various textile waste materials to fiber by passing them through a machine called a garnett, which is similar to a card.

Gilling - See Pin Drafting.

Gray Fabric - See Greige Fabric.

Grease Wool - Wool shorn from the sheep, unscoured and in its natural state.

Greige Fabric - A fabric just off the loom or knitting machine, i.e., in an unfinished state.

Grey Fabric - See Greige Fabric.

Hand - The qualities of a fabric, e.g., softness, firmness, elasticity, fineness, resilience, and other qualities perceived by touch.

Hank - A skein of yarn.

Heat-Setting - The process of imparting dimensional stability and often other desirable properties such as wrinkle resistance and improved heat resistance to man-made fibers, yarns, and fabrics by means of either moist or dry heat.

Heat-Transfer Printing - See Printing.

Heddle - A cord around steel wire, or thin flat strips with a loop or eye near the center through which one or more warp threads pass on the loom so that its movement may be controlled in weaving. The heddles are held at both ends by the harness frame. They control the weave pattern and shed as the harnesses are raised and lowered during the weaving.

High Temperature Dyeing - See Dyeing.

Hue - The attribute of colors that permits them to be classed as red, yellow, green, blue, or an intermediate between any contiguous pair of these colors.

Hydrophobic - Lacking affinity for, or the ability to absorb water.

J-Box - A J-shaped holding device used in continuous operations to provide varying amounts of intermediate material storage such as in wet processing of fabrics and in tow production. The material is fed at the top and is plaited down to fill the long arm before being withdrawn from the short arm.

Jet Dyeing Machine - A high-temperature piece-dyeing machine which circulates the dye liquor through a Venturi jet, thus imparting a driving force to move the fabric. The fabric, in rope form, is sewn together to form a loop.

Jig - A dyeing machine in which the fabric in open-width form is transferred repeatedly from one roller to another, passing each time through a batch of relatively small volume. Jigs are used for scouring, dyeing, bleaching and finishing.

Jute - A bast fiber used for sacking, burlap, and twine, and as a backing material for tufted carpets.

Kier - A large metal tank, capable of being heated uniformly and used for wet processing.

Kier Boiling - The process of boiling cellulosic materials in alkaline liquors in a kier at or above atmospheric pressure.

Knitting - A method of constructing fabric by interlocking a series of loops of one or more yarns. The two major classes of knitting are warp knitting and weft knitting:

a. Warp Knitting - A type of knitting in which the yarns generally run lengthwise in the fabric. The yarns are prepared as warps on the beams with one or more yarns for each needle. Examples of this type of knitting are milanese, raschel, and tricot knitting.

   1. Milanese Knitting - A type of run-resistant warp knitting with a diagonal rib effect using several sets of yarns.

   2. Raschel Knitting - A versatile type of warp knitting made in plain and jacquard patterns; the latter can be made with intricate eyelet and lacy patterns and is often used for underwear fabrics. Raschel fabrics are coarser than other warp knit fabrics, but a wide range of fabrics can be made. Raschel knitting machines have one or two sets of latch needles and up to thirty sets of guides.

   3. Tricot Knitting - A run-resistant type of warp knitting in which either single or double sets of yarn are used.

B. Weft Knitting - A common type of knitting, in which one continuous thread runs crosswise in the fabric making all of the loops in one course. Weft knitting types are circular and flat knitting:

1. Circular Knitting - The fabric is produced on the knitting machine in the form of a tube, the threads running continuously around the fabric.

2. Flat Knitting - The fabric is produced on the knitting machine in flat form, the threads alternating back and forth across the fabric. The fabric can be given shape in the knitting process by increasing or decreasing the loops. Full-fashioned garments are made on a flat knitting machine.

Kusters Dyeing Range - Continuous dye range for carpets. The unit wets the carpet, applies dyes and auxiliary chemicals by means of a doctor blade, fixes the dyes in a festoon steamer, and washes and dries the carpet in one pass through the range. An optional auxiliary unit may be installed to randomly drip selected dyes onto the background shade for special styling effects. This process is called TAK dyeing.

Lap - A continuous, considerably compressed sheet of fiber tufts which is rolled under pressure into a cylindrical package, usually weighing 40 to 50 pounds.

Latex - A milky rubber raw material used as a backing for carpets.

Leveling - Migration of dye molecules leading to uniform distribution of dye in a dyed material. Leveling may be a property of the dye or it may require chemical assistance.

Lightfastness - The degree of resistance of dyed textile materials to the color-destroying influence of sunlight.

Long Staple - A long fiber. In reference to cotton, long staple indicates a fiber length of not less than 1 1/8 inches. In reference to wool, the term indicates fiber 3 to 4 inches long suitable for combing.

Loom - A machine for weaving fabric by interlacing a series of vertical, parallel threads (the warp) with a series of horizontal, parallel threads (the filling). The warp yarns from a beam pass through the heddles and reed, and the filling is shot through the "shed" of warp threads by means of a shuttle or other device and is settled in place by the reed and lay. The woven fabric is then wound on a cloth beam. The principal elements of the loom are the shedding, picking, and beating-up devices. In shedding, a path is formed for the filling by raising some warp threads while others are left down. Picking consists essentially of projecting the filling yarn from one side of the loom to the other. Beating-up forces the pick, which has just been left in the shed, up to the fell of the fabric. This is accomplished by the reed which is brought forward with some force by the lay.

Loop Pile - Carpet construction in which the tufts are formed into loop from the supply yarn.

Lubricant - An oil or emulsion finish applied to the fibers to prevent damage during textile processing or to the knitting yarns to make them more pliable.

Man-made Fiber - A class name for the various genera of fibers (including filaments) produced from fiber-forming substances which may be: (1) polymers synthesized from chemical compounds, e.g., acrylic, nylon, polyethylene, polyurethane, and polyvinyl fibers; (2) modified or transformed natural polymers, e.g., alginic and cellulose-based fibers such as acetates and rayons; or (3) mineral, e.g., glass. The term man-made usually refers to all chemically produced fibers to distinguish them from the truly natural fibers such as cotton, wool, silk, flax, etc.

Mercerization - A treatment for cotton yarn or fabric to increase its luster and affinity for dyes. The material is immersed under tension in a cold sodium hydroxide (caustic soda) solution in warp, skein form, or in the piece, and is later neutralized in acid. The process causes a permanent swelling of the fiber and thus increases its luster.

Metallized Dyes - See Dyes.

Moiré - A wavy or watery effect on a textile fabric, especially a corded fabric of silk, rayon or one of the man-made fibers.

Mordant - A chemical used in some textile fibers to provide affinity for dyes.

Muft - A loose skein of textured yarn prepared for dyeing or bulking.

Muff Dyeing - See Dyeing.

Naphthol Dyes - See Dyes.

Napping - A finishing process that raises the surface fibers of a fabric by means of passage over rapidly revolving cylinders covered with metal points or teasel burrs. Outing, flannel, and wool broadcloth derive their downy appearance from this finishing process. Napping is also used for certain knit goods, blankets, and other fabrics with a raised surface.

Narrow Fabric - Any nonelastic woven fabric, 12 inches or less in width, having a selvage on either side, except for ribbon or seam binding.

Natural Fiber - A class name for the various genera of fibers (including filaments) of (1) animal, (2) mineral, or (3) vegetable origin. For example: (1) silk and wool, (2) asbestos, and (3) cotton, flax, jute, and ramie.

Nep - A small knot of entangled fibers that usually will not straighten to a parallel position during carding or drafting.

Noil - A short fiber which is rejected in the combing process of yarn manufacture.

Opening - 1. A preliminary operation in the processing of staple fiber. Opening separates the compressed masses of staple into loose tufts and removes the heavier impurities. 2. An operation in the processing of tow that substantially increases the bulk of the tow by separating the filaments and deregistering the crimp.

Optical Brightener - A colorless compound which, when applied to the fabric, absorbs the ultraviolet rays in light and emits them in the visible spectrum.

Package Dyeing - See Dyeing, Yarn Dyeing.

Padding - The application of a liquor or paste to textiles either by passing the material through a bath and subsequently through squeeze rollers, or by passing it between squeeze rollers, the bottom one of which carries the liquor or paste.

Paddle Dyeing Machine - A machine used for dyeing garments, hosiery, and other small pieces which are packaged loosely in mesh bags. The unit consists of an open tank and revolving paddles that circulate the bags in the dyebath.

Pad Dyeing - See Dyeing.

Permanent Press - A term describing a garment which has been treated so that it retains its smooth appearance, shape and creases or pleats in laundering. In such garments, no ironing is required, particularly if the garment is tumble dried. Permanent press finishing is accomplished by several methods; two of the most common are: (1) A fabric containing both a thermoplastic fiber and cotton or rayon, may be treated with a special resin which, when cured, imparts the permanent shape to the cotton or rayon component of the fabric. The resin-treated fabric may be precured (i.e., cured in finishing and subsequently pressed in garment form at a higher temperature to achieve the permanent shape) or postcured (not cured until the finished garment has been sewn and pressed into shape). In both cases, the thermoplastic fiber in the garment is set in the final heat treatment. This fiber, when heat-set, also contributes to the permanence of the garment shape, but the thermoplastic component of the blend is needed for strength since the cotton or rayon component is somewhat degraded by the permanent-press treatment. (2) Garments made from a fabric containing a sufficient amount of a thermoplastic fiber, such as polyester, nylon, or acrylic, pressed with sufficient pressure and time to achieve a permanent garment shape.

Photographic Printing - See Printing.

Picking - 1. A process which continues the opening and cleaning of staple and forms a continuous fiber sheet (or lap), which is delivered to the card. 2. The operation of passing the filling through the warp shed during weaving.

Piece Dyeing - See Dyeing.

Pigment Printing - See Printing.

Pile - 1. A fabric effect formed by introducing tufts, loops, or other erect yarns on all or part of the fabric surface. Types of pile are warp, filling, and knotted pile, or loops produced by weaving an extra set of yarns over wires which are then drawn out of the fabric. Plain wires leave uncut loops; wires with a razor-like blade produce a cut pile surface. Pile fabric may also be made by producing a double-cloth structure woven face to face, with an extra set of yarn interlacing with each cloth alternately. The two fabrics are cut apart by a traversing knife, producing two fabrics with a cut pile face. Pile should not be confused with nap. Corduroys are another type of pile fabric, where long filling floats on the surface are slit, causing the pile to stand erect. 2. In carpets, pile refers to the face yarn, as opposed to backing or support yarn. Pile carpets are produced by either tufting or weaving. (Also see Cut Pile and Loop Pile).

Pin Drafting - Any system of drafting in which the orientation of the fibers relative to one another in the sliver is controlled by pins.

Plying - Twisting together two or more single yarns or ply yarns to form, respectively, ply yarn or cord.

Pressure Dyeing - See Dyeing.

Printing - A process for producing a pattern on yarns, warp, fabric, or carpet by any of a large number of printing methods. The color or other treating material usually in the form of a paste, is deposited onto the fabric which is then usually treated with steam, heat, or chemicals for fixation. Various types of printing are described below. (Also see Dyeing).

1. Methods of Producing Printed Fabrics:

   a. Block Printing - The printing of fabric by hand, using carved wooden or linoleum blocks, as distinguished from printing by screens or rollers.

   b. Blotch Printing - A process wherein the background color of a design is printed rather than dyed.

c. Burn-Out Printing - A method of printing to obtain a raised design on a sheer ground. The design is applied with a special chemical onto the fabric woven with different pairs of threads of different fibers. One of the fibers is then destroyed locally by chemical action. Burn-out printing is often used on velvet. The product of this operation is known as a burnt-out print.

d. Direct Printing - A process wherein the colors for the desired designs are applied directly to the white or dyed cloth, as distinguished from discharge printing and resist printing.

e. Discharge Printing - In "white" discharge printing, the fabric is piece dyed, then printed with a paste containing a chemical which reduces the dye and hence removes the color where the white designs are desired. "Colored" discharge printing is similar except that a color is added to the discharge paste in order to replace the discharged color with another shade.

f. Duplex Printing - A method of printing a pattern on the face and the back of a fabric with equal clarity.

g. Etching - See Burn-Out Printing.

h. Extract Printing - See Discharge Printing.

i. Heat-Transfer Printing - A method of printing fabric of polyester or other thermo-plastic fibers with disperse dyes. The design is transferred from preprinted paper onto the fabric by contact heat. Having no affinity for paper,the dyes are absorbed by the fabric. The method is capable of producing well-defined clear prints.

j. Photographic Printing - A method of printing from photoengraved rollers. The resultant design looks like a photograph. The designs may also be photographed on a silk screen which is used in screen printing.

k. Pigment Printing - Printing by the use of pigments instead of dyes. The pigments do not penetrate the fiber but are affixed to the surface of the fabric by means of synthetic resins which are cured after application to make them insoluble. The pigments are insoluble, and application is in the form of water-in-oil or oil-in-water emulsions of pigment pastes and resins. The colors produced are bright and generally fast except to crocking.

l. Resist Printing - A printing method in which the design is produced: (1) by applying a resist agent in the desired design, then dyeing the fabric, in which case the design remains white although the rest of the fabric is dyed, or (2) by including a resist agent and a dye in the paste which is applied for the design, in which case the color of the design is not affected by subsequent dyeing of the fabric background.

m. Roller Printing - The application of designs to fabric, using a machine containing a series of engraved metal rollers positioned around a large padded cylinder. Print paste is fed to the rollers and a doctor blade scrapes the paste from the unengraved portion of the roller. Each roller supplies one color to the finished design, and as the fabric passes between the roller and the padded cylinder, each color in the design is applied. Most machines are equipped with eight rollers, but some have sixteen.

n. Rotary Screen Printing - A combination of roller and screen printing in which a perforated cylindrical screen is used to apply the color. Color is forced from the interior of the screen onto cloth.

o. Screen Printing - A method of printing similar to using a stencil. The areas of the screen through which the coloring matter is not to pass are filled with a waterproof material. The printing paste which contains the dye is then forced through the untreated portions of the screen onto the fabric below.

p. Warp Printing - The printing of a design on the sheet of warp yarns before weaving. The filling is either white or a neutral color, and a grayed effect is produced in the areas of the design.

2. Methods of Producing Printed Carpets:

a. Mitter Printing Machine - A rotary carpet printing machine with up to eight stainless steel mesh screens, and with cylindrical squeegees of moderately large diameter in each rotary screen. The unit has a steaming zone for dye fixation.

b. Stalwart Printing Machine - A carpet printing machine in which the color is applied to the carpet with a neoprene sponge laminated to the pattern. The pattern is cut in a rubber base attached to a wooden roll. It is very similar to relief printing. Used primarily for overprinting random patterns on dyed carpets. Suitable for shags and plush carpets as well as level loop and needle tuft types.

c. Zimmer Flatbed Printing Machine (Peter Zimmer) - A carpet printing machine which uses flat screens and dual, metal-roll squeegees. The squeegees are operated by electromagnets to control the applied pressure. The unit also has a steamer for dye fixation. The Zimmer flatbed machine is normally used for carpets of low to medium pile heights. Very precise designs are possible but speeds are slower than with rotary screen printers.

d. Zimmer Rotary Printing Machine (Johannes Zimmer) - A three-step rotary carpet printing machine consisting of (1) rotary screens with small-diameter steel-roll squeegees inside, with pressure adjusted electromagnetically for initial dyestuff application, (2) infrared heating units to fix the dyes on the tuft tips, and

(3) application of low-viscosity print paste, followed by steaming for complete penetration of dyes into tufts.

e. Zimmer Rotary Printing Machine (Peter Zimmer) - A rotary carpet printing machine in which each rotary screen has a slotted squeegee inside to feed the print pastes through the screens to the carpet. Pressure of the print paste is adjusted by hydrostatic head adjustments.

Print Paste - The mixture of gum or thickener, dye and appropriate chemicals used in printing fabrics. Viscosity varies according to the types of printing equipment, the type of cloth, the degree of penetration desired, etc.

Quilling - The process of winding filling yarns, for weaving, onto filling bobbins, or quills, in preparation for use in the shuttle.

Raw Fiber - A textile fiber in its natural state, such as silk "in the gum" and cotton as it comes from the bale.

Reed - A comb-like device on a loom which spaces the warp yarns and also beats each succeeding filling thread against that already woven. The reed usually consists of a top and bottom rib of wood into which metal strips or wires are set. The space between two adjacent wires is called a dent and the warp is drawn through the dents. The fineness of the reed is calculated by the number of dents per inch.

Refractory - A term used in connection with organic compounds indicating that they are non-biodegradable or resistant to biological treatment and degradation.

Reserve Dyeing - See Dyeing, Reserve Dyeing.

Resin-Treated - Usually, a term descriptive of a textile material which has received an external resin application for stiffening or an internal fiber treatment (especially of cellulosics) to give wrinkle resistance or wash-and-wear characteristics.

Resist Dyeing - See Dyeing, Reserve Dyeing.

Resist Printing - See Printing.

Retained Sludge - That sludge that is generated by aerated biological degradation of textile wastewaters. The rate of sludge generation is very slow in certain areas of the textiles industry (e.g., knit fabric dyeing and finishing) and there is no need to dispose of the small amounts of sludge. This sludge is accumulated over several years and stored in the wastewater treatment pond.

Retarder - A chemical which, when added to the dyebath, decreases the rate of dyeing but does not affect the final exhaustion.

Roller Printing - See Printing.

Rope - Fabric in process without weft tension, thus having the appearance of a thick rope.

Rotary Screen Printing - See Printing.

Roving - 1. In spun yarn production, an intermediate state between the sliver and the yarn. Roving is a condensed sliver which has been drafted, twisted, doubled, and redoubled. The product of the first roving operation is sometimes called slubbing. 2. The operation which produced roving (see 1).

Sanforizing - A mechanical process to preshrink the fabric.

Scouring - An operation to remove the sizing and tint used on the warp yarn in weaving and, in general, to clean the fabric prior to dyeing.

Screen Printing - See Printing.

Selvage or Selvedge - The narrow edge of the woven fabric that runs parallel to the warp. It is made with stronger yarns in a tighter construction than the body of the fabric to prevent raveling. A fast selvage encloses all or part of the picks, and a selvage is not fast when the filling threads are cut at the fabric edge after every pick.

Shadow Printing - See Printing, Warp Printing.

Shearing - A dry finishing operation in which the projecting fibers are mechanically cut or trimmed from the face of the fabric. Woolen and worsted fabrics are almost always sheared. Shearing is also widely employed on other fabrics, especially on napped and pile fabrics where the amount varies according to the desired height of the nap or pile. For flat-finished fabrics such as gabardine, a very close shearing is given.

Shuttle - A boat-shaped device, usually made of wood with a metal tip, that carried the filling yarns through the shed in the weaving process. It is the most common weft-insertion device. The shuttle holds a quill, or pirn, on which the filling yarn is wound. It is equipped with an eyelet at one end to control the rate. The filling yarn is furnished during the weaving operation.

Singeing - The process of burning off protruding fibers from yarn or fabric by passing it over a flame or a heated copper plate. Singeing gives the fabric a smooth surface and is necessary for fabrics which are to be printed and for those fabrics where smooth finishes are desired.

Single Knit Fabrics - A fabric constructed with one needle bed and one set of needles, also called plain knit.

Sizing - 1. A generic term for compounds which are applied to the warp yarn to bind the fiber together and stiffen the yarn to provide abrasion resistance during weaving. Starch, gelatin, oil, wax, and man-made polymers such as polyvinyl alcohol, polystyrene, polyacrylic acid, and polyacetates are employed. 2. The process of applying sizing compounds. (Also see Slashing). 3. The process of weighing sample lengths of yarn to determine the count.

Skein - A continuous strand of yarn or cord in the form of a collapsed coil. It may be of any specified length and is usually obtained by winding a definite number of turns on a reel under prescribed conditions.

Skein Dyeing - See Dyeing.

Slashing - A process of sizing warp yarns on a slasher. (Also see Sizing, 1).

Sliver - A continuous strand of loosely assembled fibers without twist. The sliver is delivered by the card, the comber, or the drawing frame. The production of sliver is the first step in the textile operation that brings staple fiber into a form that can be drawn (or reduced in bulk) and eventually twisted into a spun yarn.

Slubber - A machine used in textile processes prior to spinning which reduces the sliver and inserts the first twist.

Slubbing - The product of the slubber, it is the intermediate stage between sliver and roving.

Solution-Dyeing - See Dyeing, Mass-Colored.

Solvent Dyeing - See Dyeing.

Space Dyeing - See Dyeing.

Spin-Drawing - The reduction of roving during spinning by a roller drafting mechanism similar to that used on the roving frame.

Staple - Natural fibers or cut lengths from filaments. The staple length of natural fibers varies from less than 1 inch as with some cotton fibers to several feet for some hard fibers like linen. Man-made staple fibers are cut to a definite length, from 8 inches down to about 1 1/2 inches (occasionally down to 1 inch), so that they can be processed on cotton, woolen, or worsted yarn spinning systems. The term staple (fiber) is used in the textiles industry to distinguish natural or cut length man-made fibers from filament.

Stock Dyeing - See Dyeing.

Stripping - 1. A chemical process for removing color from dyed cloth by the use of various chemicals. Stripping is done when the color is unsatisfactory and the fabric is to be redyed. 2. The physical process of removing fiber that is embedded in the clothing of a card.

Suint - The dried perspiration of sheep, deposited in the wool, yielding potash.

Sulfur Dyes - See Dyes.

TAK Dyeing - See Kusters Dyeing Range.

Tenter Frame - A machine that dries the fabric to a specified width under tension. The machine consists essentially of a pair of endless chains on horizontal tracks. The fabric is held firmly at the edges by pins or clips on the two chains, which diverge as they advance through the heated chamber, adjusting the fabric to the desired width.

Thermal Fixation - See Dyeing.

Thread - 1. A slender, strong strand or cord, especially one designed for sewing or other needle work. Most threads are made by plying and twisting yarns. A wide variety of thread types are in use today, e.g., spun cotton and spun polyester, core-spun cotton with a polyester filament core, polyester or nylon filaments (often bonded), and monofilament threads. 2. A general term for yarns used in weaving and knitting, as in "thread count" and "warp threads".

Top - 1. A wool sliver which has been combed to straighten the fibers and remove short fibers; an intermediate stage in the production of worsted yarn. 2. A similar untwisted strand of man-made staple delivered by the comb or made directly from tow.

Top Dyeing - 1. The process of covering already dyed fiber with an additional dye, not necessarily of the same color or class, to obtain the desired shade. 2. The dyeing of top in package form.

Tow - A large strand of continuous man-made fiber filaments without definite twist collected in loose, rope-like form, usually held together by crimp.

Tubular Fabric - A fabric woven or knit in a tubular form with no seams, such as seamless pillowcases, most knit underwear fabrics, and seamless hosiery.

<u>Tufted Carpet</u> - Carpet produced by a tufting machine instead of a loom. It is an outgrowth of hand-tufted bedspreads. Today, broadloom tufting machines produce over 90 per cent of all domestic carpeting. Tufting machines are essentially multineedle sewing machines which push the pile yarns through a primary backing fabric and hold them in place to form loops as the needles are withdrawn. The loops are then either released for loop-pile carpets or cut for cut-pile carpets. The pile yarns may be either predyed or uncolored in which case, the greige carpet is then piece-dyed or printed. In either case, a latex or other binding agent is applied to the backstitch to lock the tufts in place and to secure the secondary backing fabric. Formerly, all carpets were woven, either by hand or machine. The vastly greater productivity of tufting has revolutionized the carpet industry and has made soft floor coverings available to the mass market for the first time.

<u>Vat Dyes</u> - See Dyes.

<u>Warping</u> - The operation of winding the warp yarn onto a beam in preparation for weaving or warp knitting. Also called beaming.

<u>Warp-Knit Fabric</u> - A fabric that is knit with the yarns running lengthwise, e.g., tricot, milanese, and raschel.

<u>Warp Printing</u> - See Printing.

<u>Warp Sizing</u> - See Slashing.

<u>Washfastness</u> - The resistance of a dyed fabric to loss of color or change in properties during home or commercial laundering.

<u>Wasted Sludge</u> - Excess sludge generated in a textile mill wastewater treatment system that must be removed from the system and disposed of.

<u>Weaving</u> - The method or process of interlacing two yarns of similar materials so that they cross each other at right angles to produce a woven fabric. The warp yarns, or ends, run lengthwise in the fabric, and the filling threads (weft), or picks, run from side to side. Weaving may be done on a power or hand loom or by several hand methods.

<u>Winding</u> - The transfer of a yarn or thread from one type of package to another (e.g., from cakes to cones).

<u>Wool</u> - The term is usually used for the fleece of sheep, but according to the Textile Fiber Products Identification Act, wool is defined for purposes of labeling as: "The fiber from the fleece of the sheep or lamb or hair of the Angora or Cashmere goat (and may include the so-called specialty fibers from the hair of the camel, alpaca, llama, and vicuna) which has never been reclaimed from any woven or felted wool product."

Wool is used in a variety of blends in which it is combined with nearly all natural or man-made fibers. Wool fibers have scales which tend to interlock with each other, binding the fibers together. This process is called felting. In blends, particularly those with man-made fibers, wool is used to improve the feel or appearance of finished products. Man-made fibers are sometimes blended with wool to enable the spinning of very fine or loosely twisted yarns with increased tensile strength or to produce ease-of-care properties. Wool can be treated to control shrinkage, to provide resistance to damage by moths, to impart stain resistance, and to set permanent creases in fabrics.

Woolen System - The fundamental system of making yarns for woolen fabrics. In yarns spun on the woolen system, the fibers are not parallel but are crossed in what appears to be a haphazard arrangement. After blending, fibers produced on the woolen system are evenly distributed in carding on two, three, or even four cards. From here, the split web, called roving, goes to the spinning frame. In addition to wool, man-made fibers, cotton, wastes, and noils can be processed on the woolen system. In general, the fibers used are shorter and more highly crimped than those used on the worsted system and are of the type which can be fulled.

Worsted System - A system of textile processing for manufacturing spun yarns from staple fibers usually over 3 inches in length. The main operations are carding, combing, drafting, and spinning. There are three basic systems of worsted yarn spinning: the Bradford (or English system), the French (Alsation or Continental system), and the American system.

Woven Fabric - A fabric composed of two sets of yarns, warp and filling, formed by weaving, which is the interlacing of these sets of yarns to form a fabric. There may be two or more warps and fillings in a fabric, depending on the complexity of the pattern. The manner in which the two sets of yarns are interlaced determines the weave. By using various combinations of the three basic weaves (i.e., plain, twill, and satin), it is possible to produce an almost unlimited variety of fabrics. Other effects may be obtained by varying the type of yarns, filament or spun, fiber types, twist levels, etc.

Yarn - A generic term for a continuous strand of textile fibers, filaments, or material in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric. Yarn occurs in the following forms: (1) a number of fibers twisted together (spun yarn), (2) a number of filaments laid together without twist (a zero-twist yarn), (3) a number of filaments laid together with a degree of twist, (4) a single filament with or without twist (a monofilament), or (5) a narrow strip of material, such as paper, plastic film, or metal foil, with or without twist, intended for use in a fabric.

Yarn Dyeing - See Dyeing.

APPENDIX B

DIRECTORY OF TREATMENT AND DISPOSAL CONTRACTORS ENCOUNTERED IN THE TEXTILES INDUSTRY

Category A - Wool Scouring

Containers - None
Sludge - None

Category B - Wool Fabric Dyeing and Finishing

Containers -	L.R.J. Enterprise 109 Dwayne Drive Dublin, Georgia	General Purpose Landfill

Sludges - None

Category D - Woven Fabric Dyeing and Finishing

Containers -	Herman Garner Lexington, North Carolina	General Purpose Landfill
	Truman Dogget Summerfield, N.C.	General Purpose Landfill
	Murden Sanitation Service Orangeburg, S.C.	General Purpose Landfill
	Kenyon Bros. Kenyon, R. I.	General Purpose Landfill
	Benjamin Luchka Wood River Junction, R.I.	General Purpose Landfill
	City of Lancaster Lancaster, S.C.	General Purpose Landfill
	Spartan Waste Control, Inc. Greenville, S.C.	General Purpose Landfill
	Opelika Scrap Material Opelika, Alabama	General Purpose Landfill
	Container & Disposal Co. Asheville, N.C.	General Purpose Landfill
	Sanitary Container Service Greensboro, N.C.	General Purpose Landfill

Category D (continued)

Containers - (cont.)	Puritan Industrial Maintenance Spartansburg, S.C.	General Purpose Landfill
	Buzhardt Trash Service Greenwood, S.C.	General Purpose Landfill
	Waynesboro Nursery Waynesboro, Va.	General Purpose Landfill
Sludges -	Steve Cash Waynesboro, Va.	Farm Spreading

Category E - Knit Fabric Dyeing and Finishing

Containers -	Chattanooga Disposal Co. Chattanooga, Tenn.	General Purpose Landfill
	Murden Sanitation Pine Hill Community Orangeburg, S.C.	General Purpose Landfill
	Sperry Truck Co. Glens Falls, N.Y.	General Purpose Landfill
	Greenwood Disposal Co. Lowell, Mass.	General Purpose Landfill
	B & E Garbage Service Mullins, S.C.	General Purpose Landfill
	John T. Rice & Sons Clinton, S.C.	General Purpose Landfill
	Otis Wells Newberry, S.C.	General Purpose Landfill
	City of Farmville Farmville, N.C.	General Purpose Landfill
	Container Service & Disposal Co. Asheville, N.C.	General Purpose Landfill
	City of Longview + Plant Longview, N.C.	General Purpose Landfill

Category E (continued)

Containers - (cont.)	Sanitation Services, Inc. Lumberton, N.C.	General Purpose Landfill
	Johnson Waste Spartanburg, S.C.	General Purpose Landfill
	Binzac Waste Removal Greenville, S.C.	General Purpose Landfill
	Garbage Disposal Service of Rutherford County Forest City, N.C.	General Purpose Landfill
	Grand Central Sanitation Pen Argyl, Pa.	General Purpose Landfill
Sludges -	Pollution Abatement Services Oswego, N.Y.	Solvent Recovery
	G.R.O.W.S. Subs. of Warner's Landfill Morrsiville, Pa.	State Approved Landfill with leachate controls

Category F - Carpet Dyeing and Finishing

Containers -	Thrifty Best Rubbish Fresno, Calif.	General Purpose Landfill
	Suburban Waste & Garbage Co. Rockingham, N.C.	General Purpose Landfill
	Browning and Ferris' Chattanooga Waste Disposal Service Chattanooga, Tenn.	General Purpose Landfill
	LaGrange Disposal Co. LaGrange, Georgia	General Purpose Landfill
	Simon & Sons LaGrange, Georgia	General Purpose Landfill
	Sanitation Service System Atmore, Alabama	General Purpose Landfill
	Foothill Disposal Mountain View, Calif.	General Purpose Landfill

Category F - continued

Sludges - None

Category G - Yarn and Stock Dyeing and Finishing

Containers -	Tobacco Valley Sanitation Windsor, Conn.	General Purpose Landfill
	Waste Basket, Inc. Marion, N.C.	General Purpose Landfill
	Elliott Container Service Augusta, Georgia	General Purpose Landfill
	City of Greenville Greenville, S.C.	General Purpose Landfill
	LaGrange Disposal Co. LaGrange, Georgia	General Purpose Landfill
	Waste Handling System,Inc. Forest City, N.C.	General Purpose Landfill
	Wilkes County Sanitation Department Wilkes County, Georgia	General Purpose Landfill
	Hall-ing Refuse Co. Albany, Georgia	General Purpose Landfill

Sludges - None

APPENDIX C

SAMPLING TECHNIQUES AND ANALYTICAL METHODS

Sample Collection

Sludge samples from textile mill wastewater treatment facilities were collected from the clarifier underflow returning to the aeration pond. Four-hour composite samples for both heavy metal and chlorinated organic analyses were taken. These consisted of four, one-hour samples, thoroughly mixed. Sampling was repeated once a week for four consecutive weeks.

Samples that were analyzed for heavy metals were put in polyethylene bottles and acidified with nitric acid to a pH of 2.0. Samples that were analyzed for chlorinated organics were specially handled in sterilized glass containers to make certain no contamination occurred.

Complete characterization of the textile sludge was complicated by the nature of the sludge as well as time and money constraints. Therefore, a relatively simple analytical method was chosen and used. The sludges were determined to have a solids content of 2 per cent or less and thus, the atomic absorption method for determining total trace metals, as outlined in detail below.

Procedure for Determination of Total Trace Metals

A one-pint sample of the textile sludge was acidified at the time of collection with 50 per cent nitric acid to a pH of 2. At the laboratory, a 100 ml portion of the well mixed sample was transferred to a Griffin beaker and 5 ml of concentrated redistilled nitric acid was added. The beaker was then placed on a hot plate and the sample evaporated to dryness. This procedure must be done cautiously to avoid boiling. The beaker was then allowed to cool and another 3 ml of concentrated redistilled nitric acid was added. The beaker was covered with a watch glass and returned to the hot plate. The temperature of the hot plate must be increased so that a gentle reflux action occurs. The cycle of heating and adding additional acid was continued as necessary until the digestion process was complete (generally indicated by a light colored residue). Distilled 50 per cent hydrochloric acid was then added and the beaker warmed again to dissolve the residue. The beaker walls and watch glass was then washed down with distilled water, and the sample filtered to remove silicates and other insoluble material that could clog the atomizer. The sample volume was then adjusted to 100 ml with distilled water.

The concentrations of the metals except mercury and arsenic were measured using air/acetylene and nitrous oxide/acetylene flames. The samples were aspirated directly into the flame and the absorbance recorded.

For mercury and arsenic other analytical methods must be used and these are detailed below.

Hg (Mercury)

A 50 ml portion of the digested sample was transferred into a round bottom flask, and diluted to 100 ml with distilled water. The concentration of mercury in the sample was then measured by the flameless atomic absorption method.

As (Arsenic)

A 25 ml portion of the digested sample was transferred into an arsine generating flask. The concentration of arsenic was then determined either by the silver diethyldithiocarbamate method or by atomic absorption.

Determination of Arsenic by the Silver Diethyldithiocarbamate Method

Apparatus:
1. Arsine generator
2. Spectrophotometer

Reagents:
1. Concentrated hydrochloric acid
2. 15 per cent potassium iodide solution
3. 20 per cent stannous chloride solution in concentrated hydrochloric acid
4. 5 per cent silver diethyldithiocarbamate solution in pyridine (fumes, use and discard in hood)
5. Free zinc, 20-30 mesh
6. Stock solution, 1 mg/ml
7. 10 per cent lead acetate solution

Procedure

The sample and 30-40 ml of water was placed in a clean generator bottle, with the following reagents added stepwise: 5 ml of concentrated hydrochloric acid; 2 ml of 15 per cent potassium iodide solution; and 8 drops of 20 per cent stannous chloride solution. This was allowed to mix for 15-20 minutes, while the scrubber and absorber were prepared and assembled.

The glass wool in the scrubber was impregnated with lead acetate solution, and then 4 ml of the silver diethyldithiocarbamate solution was placed in the absorber tube. One to two grams of zinc were put into a generator tube attached to the generator bottle containing the mixture of sample with reagents. The scrubber and absorber assembly was then connected. Thirty minutes were allowed for the reaction to go to completion. The absorption at 535 nanometer was recorded and the concentration of arsenic determined.

Trace Metals in the Suspended Solids of Textile Sludges
(Suspended or/Insoluble Trace Metals)

Trace amounts of suspended (insoluble) metals in the textile sludge may be determined from the non-acidified samples which were also tested for organics. A representative volume of the non-acidified sample was centrifuged. Centrifugation was necessary because these samples cause blockage to a 0.45 micron membrane filter. The supernatant liquid was removed and the semi-solid settled materials were dewatered under suction and finally air dried in an open dish.

A known weight of the solid (from 0.5 to 2 g) was placed in a Griffin beaker (250 ml), with 5 ml of concentrated nitric acid. The beaker was covered with a watch glass and heated gently. The temperature of the hot plate was increased to digest the material. When the acid had evaporated, the beaker and the watch glass were allowed to cool. Another 5 ml of concentrated nitric acid was then added to the beaker and covered and again heated until digestion was complete. Five ml of distilled 50 per cent hydrochloric acid was then added to the dry residue and the beaker was warmed gently to dissolve the material. The watch glass and beaker walls were rinsed with distilled water to dissolve the material. The sample was then filtered to remove the insoluble material such as silicates and phosphates. The sample volume was adjusted and ready for analysis. Concentrations determined in this way were reported as ppm in suspended solids.

Determination of Solid Contents of Textile Sludges

Fifty ml volumes of the unpreserved samples were transferred to weighed evaporating dishes. The water was evaporated on a steam bath. After complete evaporation, the residues were put in an oven maintained at 100-105° C and dried to a constant weight.

Determination of Suspended Solids of Textile Sludges

Suspended solids in the textile sludge was determined by filtration of a known volume of sludge through weighed glass fiber disks. The solids retained by the disks were dried at 100-103° C to constant weights.

A glass fiber disk was placed in a membrane funnel and washed with distilled water under a vacuum. The filter disk was dried in an oven 100-105° C for 30 minutes and allowed to cool. The disk was weighed and placed in the funnel. A selected volume of sludge was then filtered under suction and washed with distilled water. The filter disk was then removed and dried at 100-105° C for one hour. After allowing it to cool to room temperature, the filter and solids were weighed on an analytical balance.

Procedure for Determination of Chlorinated Organics

The samples for organic analysis were carefully handled to avoid contamination, placed in sterile containers and returned to the laboratory, where the samples were blended and the pH adjusted to 6.5 - 7.5 with 50 per cent sulfuric acid. An aliquot of the sample was transferred into a two-liter separatory funnel and diluted to one liter. Sixty (60) ml of 15 per cent methylene chlorine in hexane was then added to the sample and the mixture was shaken vigorously for two minutes. The mixed solvent was allowed to separate from the sample and the water drawn into a one-liter Erlenmeyer flask. The organic layer was then passed through a column containing 3 to 4 inches of anhydrous sodium sulfate and collected in a flask. The water phase was returned to the separatory funnel and a second and third extraction were carried out in the same way. The extract was then concentrated on a hot water bath.

The sample was then ready to be injected into the gas chromatograph unless a need for additional sample cleanup was indicated.

Interferences in the form of distinct peaks or high background in the initial gas chromatographic analysis, as well as the physical characteristics of the extract (color, cloudiness, viscosity) and background knowledge of the sample help indicate whether cleanup was required.

When interferences are indicated, the following procedures were taken:

Acetonitrile partition was used to isolate fats and oils from the sample extracts. The previously concentrated extract was transferred to a separatory funnel with enough hexane to bring the final volume to 15 ml. The sample was then extracted four times with 30 ml portions of hexane - saturated acetonitrile. The acetonitrile phases were combined with 650 ml of distilled water and 40 ml of saturated sodium chloride solution. This was mixed thoroughly and then extracted with two 100 ml portions of hexane. The hexane extracts were combined in a one-liter separatory funnel and washed with two 100 ml portions of distilled water. The water layer was discarded and the hexane layer was poured through a 3-4 inch column of anhydrous sodium sulfate. The separatory funnel and column were then washed with three 10 ml portions of hexane. The extracts were concentrated on a hot water bath and were then ready for analysis.

Florisil Column Adsorption Chromatography was used if further cleanup was needed. The sample extract volume was adjusted to 10 ml and activated Florisil was placed in a Chromaflex column. After the Florisil was settled, a one-half inch layer of anhydrous granular sodium sulfate was added to the top. The column was pre-eluted with 50-60 ml of petroleum ether and then the sample extract was transferred into the column by decantation and subsequent petroleum ether washings. The elution rate was adjusted to about 5 ml per minute and four eluates were collected in separate flasks. The first elution was done with 200 ml of 6 per cent ethyl ether in petroleum ether; the second with 200 ml of 15 per cent ethyl ether in petroleum ether; the third with 200 ml of 50 per cent ethyl ether-petroleum ether; and the fourth with 200 ml of 100 per cent ethyl ether. The eluates were then concentrated on a hot water bath and were ready for gas chromatographic analysis.

The concentration of the organics was determined using the absolute calibration method:

$$\text{micrograms/liter} = \frac{(A)\,(B)\,(Vt)}{(Vi)\,(Vs)}$$

A = micrograms of standard per standard peak area
B = sample aliquot peak area
Vi = volume of extract injected (microliters)
Vt = volume of total extract (microliters)
Vs = volume of water extracted (milliliters)

Detailed Sampling Results

The detailed analytical results of the sampling are tabulated on the following pages.

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOOL SCOURING PLANT A-2

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	543.1	388.6	545.4	430	489	4,860
*Arsenic	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.1
Barium	5.4	3.4	3.5	11.5	5.95	59
*Cadmium	0.12	0.10	0.12	0.14	0.12	1.2
*Chromium	1.8	1.16	1.56	3.2	1.93	19
*Cobalt	0.52	0.30	0.37	0.50	0.42	4.2
*Copper	1.85	1.4	1.66	2.3	1.80	18
Iron (total)	641	3.52	496	450	485	4,820
*Lead	3.86	2.48	2.75	2.35	2.86	28
Magnesium	720	429	617	475	560	5,560
Manganese	26.0	17.3	22.1	17.5	20.7	205
*Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<2
Nickel	1.6	0.94	1.23	1.28	1.26	12.5
Potassium	1,469	1,034	1,303	1,200	1,252	12,400
	-	-	-	-		
Sodium	75.0	65.0	71.0	60.0	68.0	675
Strontium	3.08	1.92	2.42	1.3	2.18	21.6
*Zinc	13.04	10.7	9.13	10.0	10.7	106
TSS	97,870					
TS	100,700					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOOL SCOURING PLANT A-2

DESCRIPTION OF SAMPLE: Clarifier Underflow

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	18	0.0062		23	0.866
2	12	0.0256		5	0.273
3	17	0.0069		14	3.13
4	12	0.0078		7	0.83
AVERAGE	15	0.0116		12	1.27

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOOL FABRIC D & F PLANT B-7

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	23.0	0.5	1.0	3.23	6.9	11,500
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<17
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<170
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<17
*Chromium	0.01	0.14	0.17	0.30	0.16	267
*Cobalt	<0.04	<0.04	<0.04	<0.04	<0.04	<67
*Copper	0.11	0.07	<0.05	<0.05	<0.07	<117
Iron (total)	21.9	1.11	1.05	2.36	6.6	11,000
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<170
Magnesium	12.9	2.05	10.0	3.68	7.2	12,000
Manganese	12.9	0.24	0.28	5.88	4.8	8,000
*Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<1.7
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<333
Nickel	0.02	<0.02	<0.02	<0.02	<0.02	<33
Potassium	21.4	2.63	4.4	5.0	8.4	14,000
	-	-	-	-		
Sodium	48.8	81.7	75.0	124.0	82	137,000
Strontium	0.09	<0.03	0.32	<0.03	<0.1	<170
*Zinc	0.63	0.68	0.90	0.51	0.68	1,130
TSS	82					
TS	600					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOOL FABRIC D & F PLANT B-7

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	12	0.1142			
2	11	0.055			
3	11	0.048			
4	9	0.220			
AVERAGE	11	0.1093			

REMARKS:

There were insufficient suspended solids to measure quantity in solid phase.

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOVEN FABRIC D & F PLANT D-8

LOCATION ______________ (Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	10.3	12.25	14.9	14.5	13.0	1,600
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<1
Barium	<0.1	<0.1	0.17	0.11	<0.12	<15
*Cadmium	0.01	0.04	0.02	0.04	0.03	3.7
*Chromium	0.72	0.60	0.80	0.76	0.72	89
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<6
*Copper	1.91	2.17	2.38	2.10	2.14	264
Iron (total)	3.87	6.66	11.25	7.93	7.43	917
*Lead	0.13	<0.1	0.13	0.28	<0.16	<20
Magnesium	42.10	30.5	26.9	19.0	29.6	3,650
Manganese	1.26	1.16	1.15	1.26	1.20	148
*Mercury	<0.001	0.002	0.001	<0.001	<0.001	<0.1
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<25
Nickel	0.12	0.14	0.21	0.08	0.14	17
Potassium	40.63	40.52	40.30	56.00	44.40	5,480
	-	-	-	-		
Sodium	424.6	395.0	338.8	625.0	446	55,000
Strontium	0.22	0.10	0.20	0.17	0.17	21
*Zinc	14.50	19.20	18.75	15.0	16.9	2,090
TSS	5,530					
TS	8,100					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOVEN FABRIC D & F PLANT D-8

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	8	0.400		18	47.7
2	6	0.369		12	56.0
3	9	0.715		9	17.8
4	7	0.520		10	33.5
AVERAGE	7.5	0.501		12.3	38.8

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOVEN FABRIC D & F PLANT D-17

LOCATION (Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	191.25	375.0	333.3	150.0	262	12,800
*Arsenic	<0.01	0.04	<0.01	<0.01	<0.02	<0.98
Barium	2.10	0.92	2.20	1.70	1.73	85
*Cadmium	0.22	0.24	0.19	0.23	0.22	10.8
*Chromium	84.13	58.4	95.4	86.0	81.0	3,969
*Cobalt	0.16	<0.05	0.07	0.08	<0.09	<4.4
*Copper	4.36	4.62	4.63	2.10	3.93	192.6
Iron (total)	312.5	195.5	393.7	207.0	277	13,600
*Lead	0.43	1.28	1.80	1.43	1.24	61
Magnesium	50.0	39.0	22.4	25.0	34.0	1,660
Manganese	7.36	6.40	6.29	5.85	6.5	318
*Mercury	0.003	0.006	0.002	0.003	0.004	0.196
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<9.8
Nickel	1.75	1.92	1.91	1.60	1.8	88.2
Potassium	44.42	47.0	37.3	50.4	45.0	2,205
	-	-	-	-		
Sodium	383.5	567.5	581.3	875.0	602	29,500
Strontium	<0.03	0.03	0.03	0.10	<0.05	<2.45
*Zinc	141.81	158.0	179.2	159.0	159.0	7,791
TSS	13,430					
TS	20,430					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOVEN FABRIC D & F PLANT D-17

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	7	0.0630		20	29.0
2	9	0.0800		17	13.0
3	7	0.0554		23	12.8
4	5	0.1070		17	55.9
AVERAGE	7	0.0764		19	27.7

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOVEN FABRIC D & F PLANT D-18

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	26.6	44.0	55.7	43.3	42.4	4,460
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<1
Barium	0.40	0.46	0.68	0.44	0.50	53
*Cadmium	0.04	0.02	0.03	0.04	0.033	3.5
*Chromium	6.90	14.00	10.75	9.00	10.20	1,070
*Cobalt	0.72	1.32	0.96	1.17	1.04	109
*Copper	10.1	15.0	8.5	8.75	10.6	1,120
Iron (total)	26.6	65.9	51.6	45.7	47.0	4,950
*Lead	0.28	<0.1	0.13	0.1	<0.15	<16
Magnesium	13.1	12.45	12.9	12.6	12.76	1,340
Manganese	0.34	0.44	0.38	0.62	0.45	47
*Mercury	0.003	0.011	0.001	0.002	0.006	0.6
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<21
Nickel	0.13	0.35	0.47	0.30	0.31	33
Potassium	10.7	14.9	11.4	16.8	13.50	1,420
	-	-	-	-		
Sodium	477.0	580.2	700.9	437.0	549	57,800
Strontium	<0.03	<0.03	<0.03	<0.03	<0.03	<3
*Zinc	13.40	8.32	6.67	6.50	8.72	918
TSS	8,100					
TS	9,500					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOVEN FABRIC D & F PLANT D-18

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	9	0.1551		16	13.86
2	17	0.100		19	19.56
3	10	0.1778		12	14.00
4	12	0.1453		12	15.50
AVERAGE	12	0.1445		15	15.70

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOVEN FABRIC D & F PLANT D-9

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	28.8	21.0	15.9	19.0	21.2	2,930
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<1.4
Barium	0.40	<0.10	0.17	0.22	<0.22	<30
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<1.4
*Chromium	3.78	3.60	2.49	3.46	3.33	460
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<6.9
*Copper	6.65	5.15	4.35	6.43	5.64	806
Iron (total)	28.4	26.6	18.75	23.30	24.3	3,360
*Lead	<0.1	<0.1	<0.1	0.2	<0.12	<16
Magnesium	57.8	48.0	29.6	30.4	41.4	5,730
Manganese	0.20	0.58	0.49	1.14	0.60	83
*Mercury	0.002	0.009	0.002	0.002	0.005	0.7
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<28
Nickel	<0.05	0.07	0.13	0.13	<0.09	<12
Potassium	46.1	41.5	36.5	59.6	45.9	6,350
	-	-	-	-		
Sodium	654.0	580.2	661.0	844.0	685	94,700
Strontium	0.03	0.03	0.03	0.10	0.05	6.9
*Zinc	0.21	5.55	1.17	2.25	2.30	318
TSS	4,200					
TS	7,230					

Note: 5-Average ppm liquid and solids

6-Average ppm total solids (mg/g

TSS - total suspended solids

TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOVEN FABRIC D & F PLANT D-9

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	8	0.4472		21	0.336
2	4	0.1140		12	0.34
3	8	0.1440		11	2.38
4	5	0.230		13	2.25
AVERAGE	6	0.2340		14	1.33

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT WOVEN FABRIC D & F PLANT D-15

LOCATION ______________ (Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	15.4	28.75	28.80	27.50	25.1	1,420
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.6
Barium	<0.1	0.15	0.42	0.16	<0.21	<12
*Cadmium	0.03	0.06	0.04	0.06	0.048	2.7
*Chromium	5.49	10.5	6.16	5.4	6.9	390
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<2.8
*Copper	13.99	26.25	21.5	18.6	20	1,130
Iron (total)	15.16	48.1	31.6	26.8	30.4	1,720
*Lead	0.99	1.0	1.16	1.60	1.2	68
Magnesium	28.5	40.5	27.6	24.0	30.2	1,710
Manganese	0.62	0.86	0.77	0.74	0.75	42
*Mercury	0.003	0.006	0.002	<0.001	<0.003	<0.17
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<11
Nickel	0.13	0.32	0.26	0.18	0.22	12
Potassium	34.0	51.2	43.4	45.0	43.4	2,460
	-	-	-	-		
Sodium	330.7	333.3	308.9	400.0	343	19,400
Strontium	0.83	0.82	0.68	1.00	0.83	47
*Zinc	7.98	17.6	10.10	15.00	12.7	720
TSS	12,780					
TS	17,650					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: WOVEN FABRIC D & F PLANT D-15

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	9	0.0015		16	1.8
2	5	0.0014		7	2.4
3	12	0.0014		16	8.3
4	10	0.0014		13	4.5
AVERAGE	8	0.0014		13	4.3

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT KNIT FABRIC D & F PLANT E-3

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	12.5	22.5	15.9	36.0	22.0	1,630
*Arsenic	<0.01	0.04	<0.01	<0.01	<0.02	<1.5
Barium	<0.1	<0.1	<0.1	0.55	<0.2	<15
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.7
*Chromium	1.49	0.28	0.26	0.42	0.62	46
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<3.7
*Copper	4.66	0.07	0.1	0.13	1.2	89
Iron (total)	15.83	25.1	17.5	32.8	23.0	1,700
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<7
Magnesium	34.9	7.25	3.67	6.3	13.0	963
Manganese	0.52	0.06	0.06	0.05	0.17	12.6
*Mercury	0.002	0.003	0.001	0.002	0.002	0.15
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<15
Nickel	0.06	<0.05	<0.05	<0.05	<0.05	<3.7
Potassium	28.5	11.57	36.5	8.8	21.0	1,560
	-	-	-	-		
Sodium	537.5	46.2	53.1	55.0	173	12,800
Strontium	0.06	0.03	0.03	0.07	0.05	3.7
*Zinc	1.59	0.33	0.35	4.24	1.63	120
TSS	11,120					
TS	13,500					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: KNIT FABRIC D & F PLANT E-3

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	7	0.059		19	0.55
2	5	0.040		9	0.27
3	9	0.0274		8	4.40
4	8	0.0356		17	3.45
AVERAGE	7	0.0405		13	2.20

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT KNIT FABRIC D & F PLANT E-16

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	4.60	2.25	10.40	4.00	5.3	6,625
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<12
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<125
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<12
*Chromium	0.02	0.01	0.04	<0.01	<0.02	<2.5
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<62
*Copper	0.11	0.20	0.03	0.03	0.09	112
Iron (total)	4.82	5.03	12.19	4.40	6.61	8,260
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<125
Magnesium	1.81	1.15	1.40	0.86	1.30	1,625
Manganese	0.17	0.06	0.11	0.05	0.09	112
*Mercury	<0.001	0.002	0.001	<0.001	<0.0015	<1.9
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<250
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<62
Potassium	2.40	2.63	3.10	4.80	3.23	4,040
	-	-	-	-		
Sodium	59.0	79.1	83.0	59.0	70.0	87,500
Strontium	<0.03	<0.03	<0.03	<0.03	<0.03	<38
*Zinc	2.81	0.49	0.47	0.26	1.00	1,250
TSS	221					
TS	800					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: KNIT FABRIC D & F PLANT E-16

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	9	0.624		19	90.4
2	5	0.132		10	83.3
3	7	0.345		27	423.5
4	8	0.433		15	126.5
AVERAGE	7	0.384		18	180.9

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT KNIT FABRIC D & F'PLANT E-14

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	13.5	12.5	23.0	11.75	15.2	1,293
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<0.85
Barium	<0.10	0.15	0.51	0.11	0.22	18.7
*Cadmium	<0.01	0.01	<0.01	0.01	<0.01	<0.85
*Chromium	0.78	0.64	0.61	0.32	0.59	50.2
*Cobalt	<0.85	<0.05	<0.05	<0.05	<0.05	<4.2
*Copper	9.78	15.0	10.5	13.1	12.1	1,030
Iron (total)	10.75	27.40	19.70	15.52	18.30	1,557
*Lead	0.13	0.42	0.26	0.28	0.27	23
Magnesium	15.47	14.45	11.00	8.40	12.33	1,049
Manganese	0.30	0.30	0.29	0.48	0.34	29
*Mercury	0.004	0.012	0.005	0.003	0.008	0.7
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<17
Nickel	0.12	0.18	0.13	0.04	0.12	10.2
Potassium	30.52	37.30	32.00	39.00	34.70	29.53
	-	-	-	-		
Sodium	452.0	728.3	690.3	1,063.0	733	62,400
Strontium	0.06	0.03	0.07	0.07	0.06	5.1
*Zinc	1.34	4.72	4.50	2.40	3.24	276
TSS	9,230					
TS	11,750					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: KNIT FABRIC D & F PLANT E-14

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	8	0.990		16	14.9
2	10	0.199		20	10.3
3	14	0.800		17	6.15
4	12	0.520		18	8.3
AVERAGE	11	0.620		18	9.9

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT CARPET D & F PLANT F-10

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	2.3	14.7	4.52	1.24	5.7	7.20
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<12
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<120
*Cadmium	<0.01	<0.01	<0.1	0.1	<0.01	<12
*Chromium	0.08	0.14	0.02	0.10	0.08	100
*Cobalt	0.04	0.22	0.04	0.38	0.17	212
*Copper	0.15	0.46	0.15	0.50	0.32	400
Iron (total)	2.02	9.00	2.78	19.80	7.8	9,750
*Lead	<0.1	0.2	<0.1	0.1	<0.12	<150
Magnesium	0.80	1.43	0.86	1.97	1.26	1,580
Manganese	0.06	0.48	0.03	0.74	0.33	412
*Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<1.2
Molybdenum	<0.2	-	<0.2	<0.2	<0.2	<250
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<62
Potassium	3.84	4.50	3.80	8.80	5.23	6,540
	-	-	-	-		
Sodium	59.5	73.3	76.4	84.0	73	91,250
Strontium	0.03	<0.03	<0.03	<0.03	<0.03	<38
*Zinc	1.03	5.20	0.71	3.70	2.66	3,325
TSS	315					
TS	800					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: 'CARPET D & F PLANT F-10

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	14	0.0946		-	-
2	13	0.0484		-	-
3	6	0.3520		12	66.8
4	7	0.2480		11	35.6
AVERAGE	10	0.1858		11.5	51.2

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT CARPET D & F PLANT F-3

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	2.63	1.75	3.00	2.25	2.40	17.40
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<7
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<70
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<7
*Chromium	0.35	0.08	0.143	0.10	0.17	123
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<36
*Copper	0.04	0.02	<0.01	0.03	<0.03	<22
Iron (total)	1.05	0.40	1.72	0.48	0.91	660
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<70
Magnesium	3.00	2.20	3.35	2.80	2.84	2,060
Manganese	0.07	0.02	0.45	0.03	0.14	101
*Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.7
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<145
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<36
Potassium	2.10	2.10	2.00	2.00	2.05	1,490
	-	-	-	-		
Sodium	45.4	51.5	56.4	71.0	56.1	41,000
Strontium	0.03	0.03	0.03	0.07	0.04	29
*Zinc	0.17	1.00	0.18	0.04	0.35	254
TSS	160					
TS	1,380					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: CARPET D & F PLANT F-3

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	12	0.00020		14	0.735
2	7	0.00025		-	-
3	8	0.00041		23	1.425
4	9	0.00032		20	0.940
AVERAGE	9	0.0003		19	1.03

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT YARN AND STOCK D & F PLANT G-10

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	0.75	<0.50	<0.50	1.25	<0.75	<357
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<5
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<50
*Cadmium	<0.01	<0.01	<0.01	<0.01	<0.01	<5
*Chromium	0.10	0.04	0.04	0.16	0.08	38
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<24
*Copper	0.15	0.10	0.20	0.43	0.22	105
Iron (total)	0.67	0.96	1.22	2.24	1.27	605
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<50
Magnesium	0.94	0.80	0.90	0.74	0.85	405
Manganese	0.01	0.02	0.01	0.02	0.02	10
*Mercury	<0.001	0.001	<0.001	<0.001	<0.001	<0.5
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<100
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<24
Potassium	3.78	4.38	3.80	5.60	4.40	2,100
	-	-	-	-		
Sodium	356.1	407.4	408.6	687.0	465	221,000
Strontium	<0.03	0.03	<0.03	0.03	<0.03	14
*Zinc	0.77	0.89	0.58	2.50	1.20	571
TSS	182					
TS	2,100					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: YARN AND STOCK D & F PLANT G-10

DESCRIPTION OF SAMPLE:

	Liquid Phase			Suspended Phase	
SAMPLE NO.	No. of Compounds	ppm		No. of Compounds	ppm
1	6	0.0090		17	3.69
2	6	0.0063		17	2.50
3	9	0.0042		20	3.63
4	7	0.0035		18	3.45
AVERAGE	7	0.0058		18	3.32

REMARKS:

REPORT OF TRACE METALS

PROJECT NO. 469

PLANT YARN AND STOCK D&F PLANT G-3

LOCATION

(Unit = PPM)

Sample No.	1	2	3	4	5	6
Aluminum	1.14	3.50	4.76	1.75	2.80	2,276
*Arsenic	<0.01	<0.01	<0.01	<0.01	<0.01	<8.13
Barium	<0.1	<0.1	<0.1	<0.1	<0.1	<81.3
*Cadmium	<0.01	0.01	0.01	<0.01	<0.01	<8.13
*Chromium	0.02	0.06	0.04	0.01	0.03	24.4
*Cobalt	<0.05	<0.05	<0.05	<0.05	<0.05	<40.65
*Copper	0.28	0.75	0.60	0.43	0.52	423
Iron (total)	1.78	5.03	5.16	1.38	3.34	2,715
*Lead	<0.1	<0.1	<0.1	<0.1	<0.1	<81.3
Magnesium	12.50	8.40	7.35	5.06	8.33	6,772
Manganese	0.08	0.18	0.22	0.10	0.15	122
*Mercury	0.001	0.002	<0.001	0.001	<0.001	<0.813
Molybdenum	<0.2	<0.2	<0.2	<0.2	<0.2	<16.23
Nickel	<0.05	<0.05	<0.05	<0.05	<0.05	<40.65
Potassium	4.64	12.28	7.62	12.00	9.14	7,431
	-	-	-	-		
Sodium	277.0	666.6	564.7	937	611	497,000
Strontium	0.14	0.03	0.07	0.07	0.08	65.0
*Zinc	6.00	5.28	0.52	0.21	3.00	2,439
TSS	129					
TS	1,230					

Note: 5-Average ppm liquid and solids
6-Average ppm total solids (mg/g
TSS - total suspended solids
TS - total solids

Analysis for Chlorinated Hydrocarbons

PROJECT NO. 469

PLANT and LOCATION: YARN AND STOCK D & F PLANT G-3

DESCRIPTION OF SAMPLE:

SAMPLE NO.	Liquid Phase No. of Compounds	Liquid Phase ppm		Suspended Phase No. of Compounds	Suspended Phase ppm
1	8	0.0093		22	61.6
2	10	0.0350		-	-
3	5	0.0980		10	92.3
4	7	0.0850		12	76.5
AVERAGE	7.5	0.0568		14.7	76.8

REMARKS:

APPENDIX D

PARTIAL LISTING OF THE CHEMICALS MOST USED IN THE TEXTILE INDUSTRY

Chemical Type	Examples
acids	acetic, formic, hydrochloric, sulfuric and oxalic
alkalies	mono-, di-, and triethanolamines, sodium carbonate, sodium hydroxide and sodium metasilicate
bleaches	sodium hypochlorite, hydrogen peroxide, sodium perborate, sodium chlorite and peracetic
adhesives and polymers	polyvinyl acetate, polyacrylates and methacrylates, polyvinyl alcohols, polyvinyl chloride, copolymers of acrylonitrile, butadiene, styrene, polyurethanes, modified starch ethers and natural rubber latices
cross-linking agents	urea formaldehydes, formaldehyde, cyclic ethylene urea formaldehyde and methylol carbamates
carbonizing agents for wool	aluminum chloride and sulfuric acid
conditioners	ethylene glycol, propylene glycol and glycerine
catalysts	diammonium phosphate, magnesium chloride, calcium chloride, zinc nitrate and zinc chloride
detergents, soaps, dispersing agents	alkyl aryl sulfonates, alkane sulfates, sodium and amine soaps, alkyl phosphate salts, sodium polyphosphates, polyethylene oxide and polypropylene oxide condensates, sodium and potassium soaps - oleate, stearate
dye assistants, carriers, accelerants	trichlorobenzene, butyl benzoate, ortho phenylphenol, biphenyl, methyl salicylate, alkylated naphthalenes and mixed chlorinated aromatics

Chemical Type	Examples
flame retardants	polyvinyl chloride and tin oxide, chlorinated paraffins and waxes and tin oxide, THPC-tetrakishydroxymethyl phosphonium chloride, tris debrompropyl phosphate, ammonium sulfamate, ammonium bromide, ammonium phosphate, thiourea, copolymers of vinylidene chloride, tetrabromo bis phenol and copolymers of acrylonitrile and vinyl chloride
chemical finishes	polyethylene and polypropylene-softeners, polymeric hand builders, quaternary ammonium long chain aliphatics-softeners, silicon fluids-lubricants, siloxane polymers-water repellants and polyperfluoro chemicals-water and oil repellants
solvents	trichloroethane, perchloroethylene, dioxane, butyl carbital, butyl cellosolve and stoddard solvent-petroleum distillate

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*U.S. GOVERNMENT PRINTING OFFICE: 1976 340-848/72 1-3